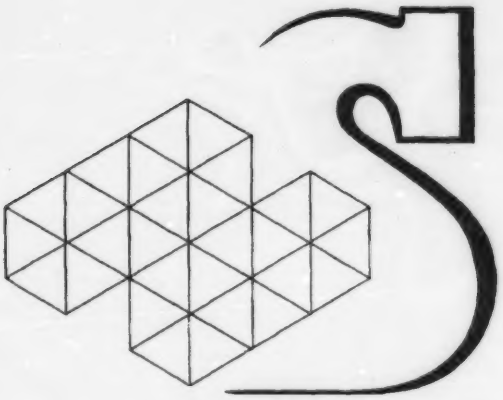

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Wet Weather Boots
Bid Evaluation Trial

PWGSC Contract No. W7711-7-7429/01-SRV
Order No. 7429-16

March 2000

DCIEM No. CR 2000-0

by

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Executive Summary

As part of the Clothe the Soldier project, the Defence and Civil Institute of Environmental Medicine (DCIEM) was tasked to assist in the final selection and acquisition of a wet weather boot. The aim of this project was to conduct the necessary user evaluation field trials and data analysis to assess the compliance of wet weather boot contenders as per the Human Performance Specifications included in the Request for Proposal and to provide the data necessary for the value for money determination.

A three-month trial was undertaken at CFB Petawawa over the period of late August to late November 1999. A battery of controlled and uncontrolled scientific Human Factors performance tests were conducted as part of a bid evaluation of three Wet Weather Boot bid contenders.

Regular force soldiers from CFB Petawawa were identified by DCIEM and assigned to either the controlled (n = 40) or the uncontrolled (n = 40) portions of the trial.. For the controlled trial, a balanced incomplete block design was used to minimize the total number of participants and the total quantity of boots required for the trial. Each participant was issued two pairs of boots such that all possible boot pairings were represented. Participants were required to alternate boot wear such that each bid contender boot was worn on every other day. The participants in the controlled trial took part in an array of tests to assess the HF performance criteria. The performance specifications evaluated included Accessibility, Compatibility, Fit and Adjustment, Functionality, Ease and Range of Motion, Physical Comfort, Durability/Protection, Water Resistance, Detection/Appearance, Thermal Protection, User Maintainability, & Weight. For the uncontrolled trial, participants in independent groups (balanced for foot size) were given one type of boot to wear for the duration of the trial period. This allowed participants to expose one boot to twice the wear time as participants in the controlled trial.

Overall, both the A and B boots were compliant with all eleven (weight was not assessed directly) Human Factors Performance Criteria. However, the C boot was non-compliant with six of the eleven Human Factors Performance Criteria. The C boot was compliant with the accessibility, compatibility, durability / protection, water resistance, and user maintainability requirements, but was non-compliant with the fit and adjustment, functionality, ease and range of movement, physical comfort, aural detection / appearance, and thermal protection requirements.

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References:

A. Human Factors Performance Requirements for Cold Wet Weather Boots, Humansystems Incorporated. Contractor Report on PWGSC Contract W7711-3-7198/XSE & W7711-6-7286/01-SRV, October 1997.

B. Request for Proposal no. W8476-9-0053/A. Wet Weather Boots for the Department of National Defense (DND). January 1999.

1. Background

As part of the Clothe the Soldier project, the Canadian Forces (CF) solicited bid submissions for a wet weather boot for the Land Forces. The Defence and Civil Institute of Environmental Medicine (DCIEM) was tasked to assist in the final selection and acquisition of this wet weather boot. In support of this acquisition, trials were carried out on off-the-shelf boots selected to meet various perceived boot requirements (Reference A). User and human factors requirements were determined, and performance-based specifications and final bid evaluation criteria for wet weather boots were developed. As part of the procurement strategy for wet weather boots, a value for money formula was developed using the human factors data collected from the critical front-end analysis trial (Reference A). Human*systems* Incorporated was subsequently tasked by DCIEM to conduct the necessary field trials to assess the compliance of bid contender submissions and acquire the data necessary for the value for money determination. Tests used to determine compliance were those described in the Human Performance Specifications (based on those developed previously (Reference A)) included in the Request For Proposal to prospective wet weather boot bid contenders (Reference B). This document reports the test procedures and results of those field trials.

2. Aim

The aim of this project was to conduct the necessary user evaluation field trials and data analysis to assess the compliance of each wet weather boot contender as per the Human Performance Specifications included in the Request for Proposal and to provide the data necessary for the value for money determination.

3. Method

3.1 Overview

A three-month trial was undertaken at CFB Petawawa over the period of late August to late November 1999. Eighty regular force soldiers participated in the evaluation of three bid submissions. During this evaluation period both controlled and uncontrolled trials were performed concurrently. Further details are provided in subsequent sections.

3.1.1 Controlled Trial:

In the controlled trial, forty (40) dismounted infantry soldiers were issued two of the three different types of boot contenders and took part in a battery of human factors tests during three sessions, each involving two days of testing. Testing sessions were scheduled at the start of the trial (late August) for fitting and sizing, the middle of the trial period (mid-October) to assess performance issues during mild, wet conditions, and finally at the end of the trial period (end November) to assess performance during cool, wet conditions. Between test sessions, participants performed their normal duties as assigned by their sub-unit and alternated boot wear between the two assigned boot contenders every other day.

Human factors tests, during each two-day testing session, included assessments of fit and adjustability, break-in time, accessibility, functionality on select obstacle and battle tasks, clothing and vehicle compatibility, physical and thermal comfort, ease and range of motion, durability, protection, detection, appearance, user maintainability, weight, and water resistance. Data collection included questionnaires, minutes of focus groups, performance measures and assessments made by human factors' observers.

3.1.2 Uncontrolled Trial:

In the uncontrolled trial, 40 soldiers from a range of infantry Arms and trades evaluated one of the boot contenders continuously for the entire three month trial period. These participants were fitted with the appropriate boot size during session 1 and then returned to their Unit to perform their normal duties for the remainder of the trial period. At the completion of the trial, available participants completed an exit questionnaire. Some participants also participated in a focus group discussion.

3.2 Trial Participants

Regular force soldiers from CFB Petawawa were identified by DCIEM as the target population of specific foot sizes required for the boots provided in the trial. Participants were selected from that population based on foot size, ratings of fit acceptance, previous experience with the Combat Boot Mark III, Warrior classification and military occupation (MOC). Trial participants were assigned to either the controlled (n = 40) or the uncontrolled (n = 40) portions of the trial, with priority given to the controlled trial. The boot sizes and quantity provided for each boot bid submission is indicated below.

Boot Sizes	
Mondopoint Size	**Quantity**
255/100	9
265/104	15
270/102	21

3.2.1 Controlled Trial:

For the controlled trial, a balanced incomplete block design was used to minimize the total number of participants and the total quantity of boots required for the trial. Each participant was issued two pairs of boots such that all possible boot pairings were represented and replicated a minimum of 6 times. With this pairing, each boot was replicated 12 times. Additional participants were included as spares in the event of participant dropout. The sample distribution of boots was issued according to the following boot pairing matrix:

	Boot B	**Boot C**
Boot A	6	6
Boot B		6

Efforts were made to ensure that each paired combination in the controlled trial was balanced for boot size (i.e. all three boot sizes were represented in each boot pairing), Warrior classification and MOC so that the participant characteristics of each boot pairing was as similar as possible. Participants were required to alternate boot wear such that each bid contender boot was worn on every other day.

3.2.2 Uncontrolled Trial:

For the uncontrolled trial, an independent measures design was used to provide participants with the opportunity to expose one boot to twice the wear time as participants in the controlled trial.

3.3 Controlled Trial Data Collection

3.3.1 Overview

The controlled trial consisted of three sessions of data collection. Each session was two days in length: one day of controlled testing repeated for each boot contender per participant. To facilitate scheduling, sometimes both boots were tested on the same day. As indicated below, data collection included controlled Human Factors testing during each session as well as questionnaires to assess the suitability of each boot worn during normal Unit duties in the time between the testing sessions. Questionnaires addressed the acceptability of the twelve HF criteria described below, as well as additional criteria necessary for the value for money determination. Between control sessions 1 and 2, each boot was evaluated during mild / wet conditions in September and early October, and between sessions 2 and 3, each boot was evaluated during cool / wet conditions in late October and November. The controlled tests are outlined in Figure 1 for each session and described in more detail below.

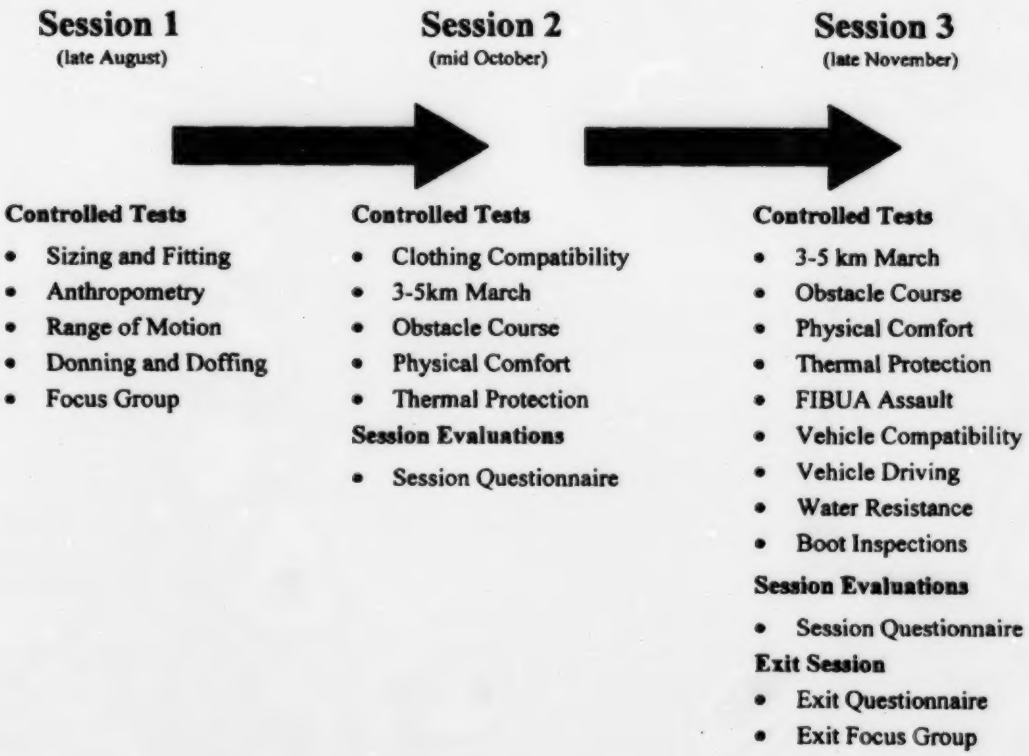


Figure 1: Data Collection during Controlled Sessions

Data was collected on the following Human Factors' Performance Criteria. Details of the tests done to acquire data on these criteria are described in section 4.0 Results.

1. Accessibility
2. Compatibility
3. Fit and Adjustment
4. Functionality
5. Ease and Range of Motion
6. Physical Comfort
7. Durability / Protection
8. Water Resistance
9. Detection / Appearance
10. Thermal Protection
11. User Maintainability
12. Weight

3.3.2 Trial Schedule:

The following two meetings bracketed the trial schedule:

Initial Briefing: Initially, participants were welcomed and introduced to the trial team. Participants were briefed on the trial schedule and data collection methods (i.e. questionnaires, focus groups, etc.). Questionnaire briefings explained the standard rating scale, the data scoring method and rules of questionnaire completion. The wet weather boot design features and characteristics were introduced to the participants.

Exit Focus Group: At the completion of the last trial day in session 3, participants were issued an Exit Questionnaire. Following the completion of the questionnaire, a focus group discussion was held.

The trial schedule for each of the three session visit is outlined below.

Session 1 was used to brief, size and fit participants. Forty participants were selected for the controlled trial and the remaining forty participants were selected for the uncontrolled trial. Participants selected for the controlled trial took part in anthropometric foot measurements, range of motion measurements, and fit assessments (including a short march).

Session 2 involved testing of the boots in mild and wet weather. Testing included assessment of durability and time to break-in, accessibility, clothing compatibility, 5 km rucksack march and obstacle course performance, and thermal and physical comfort.

Session 3 involved testing of the boots in cool and wet weather. Testing included assessment of durability which included boot inspections, 5 km rucksack march and obstacle course performance, thermal and physical comfort, Advance to Contact and FIBUA performance, and vehicle operation and compatibility.

3.4 Uncontrolled Trial Data Collection

In the uncontrolled trial, forty soldiers from a range of infantry Arms and trades were required to evaluate one of the boot bid submissions continuously for the entire three month trial period. These participants were fitted with the appropriate boot size during session 1 and then returned to their Unit to perform their normal duties for the remainder of the trial period. At the completion of the trial, these participants completed an Exit questionnaire. Some participants also took part in focus group discussions.

4. Results

4.1 Overview

This section describes the results of the tests performed to assess compliance with the HF performance-based specifications. Results are provided for tests relating to accessibility, compatibility, fit and adjustment, functionality, ease and range of movement, physical comfort, durability/protection, water resistance, aural detection/appearance, thermal protection, user maintainability, and weight. Samples of the questionnaires used in the trial are provided in Annex A.

For the controlled trial, a balanced incomplete block design was used to balance the presentation of boot pairings to participants. For the uncontrolled trial, participants in independent groups (balanced for foot size) were given one type of boot to wear for the duration of the trial period. For both the controlled and uncontrolled trials, descriptive statistical analyses (i.e. mean, standard deviation, n) were conducted using independent measures. Results include relevant items from the Human Factors Performance Criteria Tests included in the Request for Proposal (see Reference B), Exit Questionnaires and the Exit Focus Group.

Human Factors Performance Criteria Tests: Participants in the controlled trial performed tests specific to each of the HF performance criteria. Participants from the uncontrolled trial did not participate in these tests. Twenty-eight participants from the controlled trial completed the Exit Questionnaire and were included in the data analyses. In the various tests, the number of participants varies depending on the attendance of these participants during the testing sessions.

Exit Questionnaire: Participants filled out the Exit Questionnaire after they completed all the test stands and sessions for a boot type. Using the standard seven-point rating scale of acceptance, participants rated the acceptance of a number of different items related to the HF performance specifications.

Twenty-eight participants from the controlled trial completed the Exit Questionnaires. AB boot pairings were represented by 6 participants. Both AC boot pairings and BC boot pairings were each represented by 11 participants. All participants were present for at least one of the controlled sessions and/or had demonstrated experience with the activities included in the controlled sessions (e.g. marches and obstacles).

Twenty-three participants from the uncontrolled trial completed the Exit Questionnaires. The A boot was represented by 6 participants. The B boots were represented by 11 participants. The C boots were represented by 6 participants. With the exception of the Durability/Protection HF performance criteria, uncontrolled trial results have not been included because an insufficient number of observations (<12) for each boot type were collected to merit statistical analyses.

Exit Focus Group: A focus group discussion was held at the end of the trial. Separate focus groups were conducted for each boot type. Because of other military commitments, some participants were not available to take part in the Exit Focus Group. There were 13, 14 and 16 participants in the Exit Focus Groups for the A, B and C type boots respectively. The resulting comments are provided with the relevant specification below.

Soldier comments obtained during the trial as verbal or written commentary are provided to lend insight into the soldier's perceptions. These comments, and associated design suggestions, should be interpreted in the context of soldier's perceptions, opinions, and experience. These opinions may or may not reflect actual boot construction or design issues. Care must be taken if soldiers' comments are extrapolated out of the context of perceptions based on daily use of boots and the trial experience.

Data collection included task timings, participant and questionnaire ratings, and focus groups. Participants rated acceptability using the following seven-point scale (Figure 2).

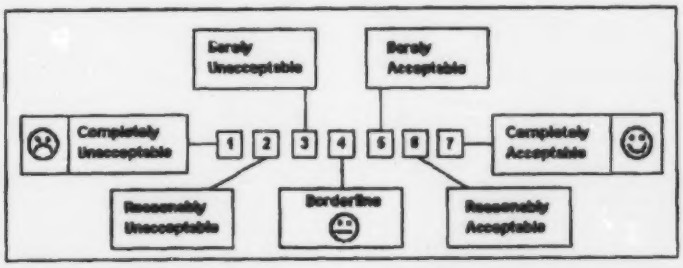


Figure 2: Standard Seven-Point Rating Scale of Acceptance

A summary of each of the HF Performance Specifications is provided in Table 1 below. The section and sub-section numbers correspond to performance specification numbers as they appear in the Request for Proposals (Reference B). In the following sub-sections, these specifications are further broken down into the 12 main criteria and discussed with respect to compliance of each of the boots with that criterion. The compliance of each boot contender with each HF performance specification is indicated as either "Pass" (indicated by a checkmark, "✓") or "Fail" (indicated by an "X"). To provide justification, this is followed with results from the tests relevant to the specification, along with a brief description of the test protocol. Performance measures indicated by participant ratings that fail to comply with the HF performance specification are highlighted with shading. Results not directly related to the HF performance specifications are sometimes provided for further detail.

Table 1: HF Performance Specifications

1.1 Most soldiers (greater than 80%) shall rate the doffing and donning of the boot as better than acceptable (i.e. >4)
1.2 Donning the boots with bare hands shall be accomplished within 40 seconds.
1.3 Doffing the boots with bare hands shall be accomplished within 20 seconds.
2.1 The boots shall not interfere with the operation of clothing, vehicles, equipment, or weapon systems.
2.2 Most soldiers (>80 %) shall rate the overall compatibility as acceptable (i.e. ≥4).
2.3 Most soldiers (>80%) shall rate the compatibility with individual items as acceptable (i.e. ≥4).
3.1 Fit shall accommodate at least 95% of the CF LF population (males and females)
3.2 Most participants (>80%) shall rate the overall adjustment of the boots as acceptable (i.e. ≥4).
3.3 Most participants (>80%) shall rate the boots as broken-in within two weeks of issue.
4.1 The individual must be able to wear the boots continuously under normal operational conditions and activities with minimal reduction in operational effectiveness.
4.2 Most soldiers (>80%) shall rate the overall functionality as acceptable (i.e. ≥4).
4.3 Most soldiers (>80%) shall rate the functionality with individual activities as acceptable (i.e. ≥4).
5.1 The boots shall not restrict plantar flexion to less than 90 degrees.
5.2 The boots shall not restrict dorsi-flexion significantly from the barefooted condition.
5.3 The boots shall not restrict ankle medial-inversion significantly from the barehanded condition.
5.4 Most soldiers (>80%) shall rate the arch, ankle, and heel support as acceptable (i.e. ≥4).
6.1 Most soldiers (>80%) shall rate the overall comfort of the boot as acceptable (i.e. ≥4).
6.2 Following marches and task simulations, most soldiers (>80%) shall rate the physical comfort of the boot as less than "painful" (i.e. <4)
6.3 Most soldiers (>80%) shall rate the sole cushioning of the boot as acceptable (i.e. ≥4).
6.4 Most soldiers (>80%) shall rate the boots' resistance to causing blisters as acceptable (i.e. ≥4).
7.1 Most soldiers (>80%) shall rate the overall durability as acceptable (i.e. ≥4).
7.2 Most soldiers (>80%) shall rate the overall protection as acceptable (i.e. ≥4).
7.3 Footwear shall be resistant to chemicals such as antifreeze, POL (Petroleum, Oil, Lubricant), battery acid, seawater, human sweat, and insect repellent (DEET).
8.1 The boot must not gain more than 350 g of water during the 2 hour wetting test, and must have less than 175 g remaining after a 2 hour drying period.
8.2 Most soldiers (>80%) shall rate the through-the-boot water resistance of the boots as acceptable (i.e. ≥4).
8.3 Most soldiers (>80%) shall rate the over-the-top water resistance of the boots as acceptable (i.e. ≥4).
9.1 Soldiers must perceive the footwear to be silent in use.
9.2 By its design and appearance, the boots shall be perceived by the soldier as providing a professional military image. Most soldiers (>80%) shall rate the appearance of the boots as acceptable (i.e ≥4).

10.1 The design and materials of the footwear shall provide thermal comfort to the feet (when worn with the sock system) during all operational activities conducted at temperatures ranging from –10 degrees centigrade to +10 degrees centigrade.
10.2 Soldiers shall not rate the overall thermal comfort, on average, as cold or hot in temperatures ranging from –10 degrees centigrade to +10 degrees centigrade.
10.3 Most soldiers (greater than 30%) shall rate the thermal comfort of the boot for its intended climatic categories as acceptable (i.e. ≥4).
10.4 Most soldiers (greater than 80%) shall rate the sweat release (water vapour permeability) of the boot as acceptable (i.e. ≥4).
11.1 Most soldiers (≥80%) shall rate the required boot care as acceptable (i.e. ≥4).
11.2 The clothing system must be maintainable and repairable by an individual without special tools under normal operational conditions.
12.1 This criterion is not intended to be a pass-fail criterion, but rather as input to the "Value for Money" calculation which will be performed if more than one bidder is found to be compliant. All other criteria being equal, a lighter boot will be chosen over a heavier boot.

4.2 Accessibility Results

1.1 Most soldiers (greater than 80%) shall rate the doffing and donning of the boot as better than acceptable (i.e. >4)	✓	✓	✓
1.2 Donning the boots with bare hands shall be accomplished within 40 seconds.	✓	✓	✓
1.3 Doffing the boots with bare hands shall be accomplished within 20 seconds.	✓	✓	✓

4.2.1 Accessibility Tests

Participants doffed and donned boots twice, paying particular attention to the ease of accessibility. Using the standard seven-point rating scale of acceptance, participants rated the acceptance of putting on and taking off the boots. The results below indicate the percentage of participants rating the items greater than 4 ("borderline"). The results also indicate the mean and standard deviations of the fastest times to don or doff the boots.

	User Acceptance Rating > 4		
Accessibility	A	B	C
Donning and Doffing	88%	86%	100%

	A		B		C	
	Mean	s.d.	Mean	s.d.	Mean	s.d.
Time to Don (seconds)	27	7	29	10	25	8
Time to Doff (seconds)	20	5	18	5	12	3

4.2.2 Exit Questionnaires

The results below indicate the percentage of participants rating the items related to accessibility as acceptable (greater than 4 ("borderline")).

Accessibility	User Acceptance Rating > 4		
	A	B	C
Putting On	94%	94%	90%
Taking Off	88%	94%	90%
Lacing	88%	94%	95%
Overall Rating – Accessibility	94%	94%	95%

4.2.3 Exit Focus Group Comments

A majority of participants believed the speed lacing eyelets could be enlarged slightly on Boots A and B to improve accessibility. The C boot eyelets were preferred because the speed lacing had slightly larger lace openings that facilitated easy tightening and loosening. Some comments also indicated a preference for one speed lace located below the comfort notch (like the C boot) to facilitate easier tightening and loosening of the lower laces and toe area.

4.2.4 Accessibility Summary

Each of the three boot types was compliant with all the accessibility human factors performance requirements. The participant ratings from both the accessibility tests and the Exit questionnaires (for Overall Accessibility) indicated that most soldiers (greater than 80%) rated the doffing and donning of all boot types as better than acceptable (i.e. >4). The mean performance timings from the accessibility test indicated that all the boot types could be donned with bare hands within 40 seconds and doffed within 20 seconds.

Although all the boot types were compliant with the accessibility performance requirements, comments during the accessibility tests and the exit focus group indicated that the accessibility of boots A and B could be improved if the eyelets were enlarged, similar to the sizing used for the C boot.

4.3 Compatibility Results

2.1 The boots shall not interfere with the operation of clothing, vehicles, equipment, or weapon systems.	✓	✓	✓
2.2 Most soldiers (>80 %) shall rate the overall compatibility as acceptable (i.e. ≥4).	✓	✓	✓
2.3 Most soldiers (>80%) shall rate the compatibility with individual items as acceptable (i.e. ≥4).	✓	✓	✓

4.3.1 Compatibility Tests

Compatibility was assessed for select items of clothing and vehicles.

Clothing:

Participants donned the appropriate clothing and were encouraged to adjust their boots to the best of their ability to accommodate each test item. Clothing items included the IECS clothing system (i.e. lightweight trousers and insulated bib pants), and rain pants. Each participant was evaluated separately under the close observation of the HF observer. CW coveralls and NBC overboots were not assessed due to limited availability of clothing items. Participants were required to rate the compatibility of the boots with each of the selected clothing combinations. HF observers noted instances of compatibility clash and accommodation required.

Vehicles:

Participants were required to rate the compatibility of the boots with the M113 Land Force vehicle while conducting tasks such as accessing hatches and doors, operating foot control pedals, and mounting the outside.

Participants doffed and donned each item of clothing or assessed vehicle compatibility, paying particular attention to instances of compatibility clash. Using the standard seven-point rating scale of acceptance, participants rated the acceptance of the item for compatibility with the boots. The results below indicate the percentage of participants rating the items as acceptable (greater than or equal to 4 ("borderline")).

Compatibility	User Acceptance Rating ≥ 4		
	A	B	C
Rain Pants	64%	73%	50%
IECS Lightweight Trousers	100%	100%	100%
IECS Insulated Bib Pants	100%	100%	100%
M113 Vehicle Compatibility	100%	100%	93%

Less than 80% of participants rated compatibility with the Rain Pants as acceptable for all boot types due to the difficulty of fitting the boot through the pant cuff. This clash is unavoidable for larger sized boots given the design of the rain pants. For the other individual clothing items and the M113 vehicle, greater than 80% of participants rated the compatibility with all boot types as acceptable (greater than or equal to 4 ("borderline")).

4.3.2 Exit Questionnaires

The results below indicate the percentage of participants rating the items related to compatibility as acceptable (greater than or equal to 4 ("borderline")).

Compatibility	User Acceptance Rating ≥ 4		
	A	B	C
Combat Trousers	100%	100%	95%
IECS Fleece Pants	100%	100%	100%
Wind Pants	100%	100%	100%
Rain Pants	93%	100%	83%
Liner Socks	80%	94%	89%
Canadian Prototype General Purpose Socks	82%	94%	68%
Norwegian Socks	100%	94%	81%
Grey Wool Socks	100%	100%	85%
Overall Rating – Compatibility	100%	100%	86%

With the exception of the Canadian Prototype General Purpose Socks, greater than 80% of participants rated the compatibility with all boot types as acceptable (greater than or equal to 4 ("borderline")). Less than 80% of participants rated compatibility with Canadian Prototype General Purpose Socks as acceptable with the C boot type. Although Canadian Prototype General Purpose Socks were used in the study, they are not regular Canadian issue socks and are not required for compliance with compatibility performance criteria.

Ratings for the following items were not included because greater than 50% of participants indicated that they had no experience with the item over the trial period: NBC IPE Coveralls, CVC Bib Pants, IECS Lightweight Trousers, IECS Insulated Bib Pants, Arctic Whites, Combat Overboots, and NBC Overboots.

4.3.3 Exit Focus Group Comments

For all boot types, none of the participants indicated noticeable or unavoidable clash with their individual clothing, equipment, or vehicles used over the trial period.

4.3.4 Compatibility Summary

Overall, none of the boot types significantly interfered with the operation of clothing, vehicles, equipment or weapon systems. Each of the three boot types was compliant with all the human factors performance requirements related to compatibility. The participant ratings from the Exit questionnaires indicated that most soldiers (greater than 80%) rated the overall compatibility of all boot types as acceptable (i.e. ≥ 4). The participant ratings from both the compatibility tests and the Exit questionnaires indicated that most soldiers (greater than 80%) rated the compatibility with individual items as acceptable (i.e. ≥ 4). As discussed above, clash experienced with the Canadian Prototype General Purpose Socks and the Rain Pants are inconsequential to the compliance of the boots with the HF performance requirements for compatibility.

4.4 Fit and Adjustment Results

3.1 Fit shall accommodate at least 95% of the CF LF population (males and females)	✓*	✓*	✓*
3.2 Most participants (>80%) shall rate the overall adjustment of the boots as acceptable (i.e. ≥ 4).	✓	✓	✓
3.3 Most participants (>80%) shall rate the boots as broken-in within two weeks of issue.	✓	✓	✗

*Assessed by DCIEM

4.4.1 Fit and Adjustment Tests

A separate study was conducted by DCIEM to assess HF performance requirement 3.1, "Fit shall accommodate at least 95% of the CF LF population (males and females). Details regarding the tests and results are provided in Annex B. Fit and adjustment ratings taken during the trial to support DCIEM are provided in Annex C.

During session 2, participants completed a between-session questionnaire to indicate the break-in time for each of the bid submissions. The results below indicate the percentage of participants that indicated that the boot was broken-in within two weeks of issue.

	% of participants		
Fit and Adjustability	A	B	C
Break-in time ≤ 14 days	100%	94%	75%

For the A and B type boots, greater than 80% of participants indicated that the boot was broken-in within two weeks. Less than 80% of participants indicated that the C boot was broken-in within two weeks of issue.

4.4.2 Exit Questionnaires

The results below indicate the percentage of participants rating the items related to fit and adjustability as acceptable (greater than or equal to 4 ("borderline")).

Fit and Adjustability	User Acceptance Rating ≥ 4		
	A	B	C
Adjust Fit	94%	88%	95%
Overall Rating – Adjustability	100%	94%	86%

For all boot types, greater than 80% of participants rated the overall adjustability of the boots as acceptable.

4.4.3 Exit Focus Group Comments

Comments during the group discussions tended to focus on the C boot. A majority of participants (69%) indicated that the C boot fit poorly in the heel because it was too wide and stiff. Some participants (44%) indicated that the C boot fit poorly in the toes. More than half (56%) of participants indicated that the poor fit of the C boot contributed to physical discomfort.

A majority of participants (61%) indicated that the lace to toe construction extended too low on the C boot, interfering with the ability of the toe to bend. The construction placed pressure on the top of the toes and caused the toes to bend an unusual location.

Half of the participants (50%) indicated that the C boot did not adequately break-in over the course of the trial because the heel construction was too stiff. Other comments also indicated that a few participants found that the boot was too high and interfered with the calf and leg muscles.

Fit with regards to insoles was split between the boot types. Half of the participants (50%) indicated that the insoles of the C boot were much better, providing better contour and support than boots A and B.

4.4.4 Fit and Adjustability Summary

A separate study was conducted by DCIEM to assess if the fit of the boots accommodated at least 95% of the CF LF population (males and females).

Results from the Exit questionnaire indicate that all the boot types were compliant with the HF Performance requirement 3.2 that greater than 80% of participants shall rate the overall adjustment of the boots as acceptable.

Results from session 2 indicated that only the A and B type boots were compliant with the HF Performance requirement 3.3. For the A and B type boots, greater than 80% of participants indicated that the boot was broken-in within two weeks. However, less than 80% of participants indicated that the C boot was broken-in within two weeks of issue. Focus group comments from a majority of the participants indicated that the heel support and toe area were very stiff and did not seem to break-in over the course of the trial period.

4.5 Functionality Results

4.1 The individual must be able to wear the boots continuously under normal operational conditions and activities with minimal reduction in operational effectiveness.	✓	✓	✓
4.2 Most soldiers (>80%) shall rate the overall functionality as acceptable (i.e. ≥4).	✓	✓	X
4.3 Most soldiers (>80%) shall rate the functionality with individual activities as acceptable (i.e. ≥4).	✓	✓	X

4.5.1 Functionality Tests

Several combat activities (i.e. rucksack marching, advance to contact and FIBUA assault, obstacle course, and vehicle driving) were undertaken to assess boot functionality. Participant functionality ratings and HF observer assessments were collected following each test. Route, terrain, pace and battle tasks were standardized between sessions. HF observers evaluated the speed, and agility effects of boot wear.

a) **Rucksack Marching:** Participants marched a distance of 3-5 km over varied terrain and grades. Rucksacks were loaded as per Battalion SOP.

b) **Advance to Contact:** The Advance to Contact included an advance over 300 meters of open ground and brush in field formation. At 100 meters from a FIBUA (Fighting in Built Up Areas) house, participants came under simulated "enemy" fire and were required to engage in fire and movement skirmishing while making maximum use of ground. The advance to contact also involved a series of ground obstacles (e.g. ditches) for the participants to climb or cross.

c) **FIBUA Assault:** Participants were required to engage in a FIBUA house clearing simulation. The participants were separated into two sections to independently assault the FIBUA house. Participants used blank ammunition. Each section simulated a breach and then cleared the house room to room, one floor at a time.

d) **Obstacle Course Performance:** An obstacle course was used to evaluate boot effects on the performance of soldier mobility tasks. Questionnaire ratings by trial participants were collected for each test. Participants performed these tests in both boot types in mild / wet weather (session 2) and cool / wet weather (session 3) conditions. At the completion of the obstacle course for each boot condition, participants completed a Functionality Questionnaire. For each obstacle, participants wore webbing. The following obstacles were undertaken consecutively as part of a single course:

Ladder Obstacle: Ascend a 10 m ladder, straddle and traverse the top bar, then descend the ladder to the ground.

Crawl: Perform a Leopard crawl while traversing a 10 m low wire obstacle.

Irish Stones: Leap one-footed from stone to stone to cross a sand pit.

Wall Obstacle: Run 3 m and climb over three low walls.

Pit Obstacle: Run up a 2 m ramp and jump down into a sand pit.

Balance Beam: Walk along a zigzag balance beam mounted 0.5 m above the ground.

Over and Under Obstacle: Climb over and under three successive poles mounted 0.5 and 1.0 meter from the ground.

Mouse Hole Obstacle: Crawl through a square, concrete mouse hole shaft for 1m and climb over and under three successive poles mounted 0.5m, 1.0m, and 0.5m above the ground.

e) **Vehicle Operation:** Boot functionality during vehicle operation (e.g. M113, Iltis, and LSVW) was evaluated using a forward slalom course. Participants were required to drive a short 2 km course with left and right turns and hills. Participants were required to rate their performance in vehicle operation in each boot submission. HF observers noted any boot issues during vehicle operation.

Using the standard seven-point rating scale of acceptance, participants rated the acceptance of the item for functionality with the boots after each test activity. The results below indicate the percentage of participants rating the items as acceptable (greater than or equal to 4 ("borderline")).

Functionality	User Acceptance Rating ≥ 4		
	A	B	C
Session 3: Rucksack March	91%	92%	57%
Session 3: Advance / FIBUA	100%	100%	92%
Session 2: Obstacle Performance	100%	100%	100%
Session 3: Obstacle Performance	100%	100%	79%
M113 Vehicle Operation	100%	100%	92%
ILTIS Vehicle Operation	100%	100%	100%
LSVW Vehicle Operation	100%	100%	92%

For the A and B type boots, greater than 80% of participants indicated that the boot was acceptable for the test activities. However, less than 80% of participants indicated that the C boot was acceptable for the rucksack march and the obstacle performance (in session 3). Results from the Functionality questionnaire indicated that less than 80% of participants rated the C boot acceptable for many aspects related to the ability to perform activities with the boots. Items rated acceptable by less than 80% of participants included running, marching, marching with rucksack, & ladder obstacles (i.e. three rung ladder). Comments and ratings also indicated that the C boot provided poor arch, ankle and heel support for some participants which contributed to poor physical comfort, poor ease and range of movement, and contributed to formation of blisters.

4.6.2 Exit Questionnaires

The Exit questionnaire results below indicate the percentage of participants rating items related to functionality as acceptable (greater than or equal to 4 ("borderline")).

Functionality (Activities)	User Acceptance Rating ≥ 4		
	A	B	C
Walking	94%	100%	78%
Running	94%	100%	68%
Marching	94%	94%	67%
Crawling	85%	100%	94%
Climbing	94%	100%	85%
Hill Climbing	93%	100%	85%
Stream Fording	92%	100%	94%
Digging	91%	100%	92%
Obstacles	94%	100%	90%
Fire and Movement	100%	100%	82%
FIBUA	100%	100%	94%
Garrison Activities	94%	100%	81%
Vehicle Exit/Entry	100%	100%	81%
Vehicle Operation	100%	100%	79%
Overall Rating – Functionality	100%	100%	77%

Ratings for the following items are not included because greater than 50% of participants indicated that they had no experience with the activity over the trial period: Parachuting, Rappelling, and Aircraft Exit/Entry.

For the A and B type boots, greater than 80% of participants indicated that the overall functionality of the boot was acceptable. However, less than 80% of participants indicated that the overall functionality of the C boot was acceptable. For the A and B type boots, greater than 80% of participants indicated that the boot was acceptable for the test items related to functionality. However, less than 80% of participants indicated that the C boot was acceptable for walking, running, marching and vehicle operation.

Participants rated the functionality of various boot features on the Exit Questionnaire. Features included calf padding, pull assist, upper, heel, sole, insert, tongue, tongue binding, eyelets, ankle flex notch, laces, toe cap, lace to toe (length), boot lining, interior threading, and exterior threading. All features, with the exception of the pull assist of boot A and C and the heel of boot C, were rated acceptable by more than 80% of participants.

4.5.3 Exit Focus Group Comments

All participants who wore the A boot expressed that they could perform duties with the A boot and that the A boot was an improvement over the in-service boot. All of these participants expressed that they would select the A boot over the B or C boot. A majority of participants liked the sole with the indented mid-sole rather than a flat sole.

All participants who wore the B boot expressed that they could perform duties with the B boot and that the B boot was an improvement over the in-service boot. Less than half (43%) indicated that they would select the B boot over the A or C boot.

Of the participants who wore the C boot, a majority (69%) of participants expressed that the lace to toe length was too long and interfered with the boots functionality. The laces put pressure on the top of the toes and pinched the top of the toes at the joint. A majority of participants (67%) also indicated that the sole lacked flexibility. This contributed to "foot smacking" when walking, and tread clogging with debris and mud. A majority of 61% of participants also expressed that the "lip" of the sole was unacceptable because it acted as a shelf for debris to collect, and often snagged on objects (i.e. clothing, vehicles, terrain, etc.). Few participants (22%) indicated that they would select the C boot over the A or B boot.

Although few people used the pull tabs on boots A and B, all participants believed it could be left on the boot design because it did not interfere with the overall functionality of the boot. The pull tabs on boot C, however, were not useful because they could not be gripped well for pulling. All participants believed the pull tabs should be removed from boot C.

4.5.4 Functionality Summary

Overall, none of the boot types significantly interfered with individuals' ability to wear the boots continuously under normal operational conditions and activities with minimal reduction in operational effectiveness. However, results from the Exit questionnaires indicated that only the A and B type boots were compliant with the HF Performance requirement 4.2. For the A and B type boots, greater than 80% of participants rated the overall functionality as acceptable. However, less than 80% of participants rated the overall functionality of the C type boot as acceptable. Focus group comments indicated that a majority of participants (69%) expressed that the lace to toe length of the C boot was too long and interfered with the boots functionality. The laces put pressure on the top of the toes and pinched the top of the toes at the joint. In addition, participants expressed that the C boot sole lacked flexibility resulting in "foot smacking" when walking, and tread clogging with debris and mud. Participants also expressed that the "lip" of the sole was unacceptable because it acted as a shelf for debris to collect, and often snagged on objects.

Results from the Functionality and Exit questionnaires indicated that only the A and B type boots were compliant with the HF Performance requirement 4.3. For the A and B type boots, greater than 80% of participants rated the functionality with individual activities as acceptable. However, less than 80% of participants rated the functionality of the C type boot as acceptable with individual activities including rucksack marching, obstacle course performance (in cold & wet conditions), walking, running, marching, and vehicle operation.

4.6 Ease and Range of Movement Results

5.1 The boots shall not restrict plantar flexion to less than 90 degrees.	✓	✓	✓
5.2 The boots shall not restrict dorsi-flexion significantly from the barefooted condition.	✓	✓	✓
5.3 The boots shall not restrict ankle medial-inversion significantly from the barehanded condition.	✓	✓	✓
5.4 Most soldiers (>80%) shall rate the arch, ankle, and heel support as acceptable (i.e. ≥4).	✓	✓	X

4.6.1 Ease and Range of Movement Tests

Ease and Range of Movement includes measures of range of motion (plantar flexion, dorsi-flexion, and medial-inversion) and ratings of acceptance for arch, ankle and heel support during various combat activities.

The results below indicate the mean and standard deviations of plantar flexion. The angle measured was between the axis of the foot and the tibia. A higher measure corresponds to an increased range of motion.

	A		B		C	
Plantar Flexion	Mean	s.d.	mean	s.d.	mean	s.d.
Plantar Flexion	104.3°	4.0°	104.3°	6.1°	99.9°	5.5°

None of the boots restricted plantar flexion to less than 90 degrees.

The results below indicate the mean and standard deviations of dorsi-flexion. The angle measured was between the axis of the foot and the tibia. For dorsi-flexion, a higher measure corresponds to a decreased range of motion. A T-test for dependent measures was performed to compare the dorsi-flexion of participants with and without the boots. The results of the statistical analyses (p-value) are provided below.

	Dorsi-Flexion with Boot		Dorsi-Flexion Barefoot		p
Dorsi-Flexion	Mean	s.d.	mean	s.d.	
Dorsi Flexion Boot A	66.6°	7.7°	63.3°	6.6°	0.114
Dorsi Flexion Boot B	65.4°	5.8°	63.7°	4.5°	0.242
Dorsi Flexion Boot C	65.3°	4.8°	62.5°	6.1°	0.059

The measures of dorsi-flexion with or without boots were not statistically different ($p<0.05$) for the any type of boot.

The results below indicate the mean and standard deviations of medial inversion. The angle measured was between the axis of the tibia and the horizontal of the floor. For medial inversion, a higher measure corresponds to a decreased range of motion. A T-test for dependent measures was performed to compare the dorsi-flexion of participants with and without the boots. The results of the statistical analyses (p-value) are provided below.

Medial Inversion	Medial Inversion with Boot		Medial Inversion Barefoot		p
	mean	s.d.	mean	s.d.	
Medial Inversion Boot A	71.3°	7.1°	70.2°	8.9°	0.056
Medial Inversion Boot B	71.3°	6.3°	68.7°	7.0°	0.001*
Medial Inversion Boot C	74.0°	6.2°	69.3°	7.3°	0.003*

For medial inversion, a higher measure corresponds to a decrease range of motion. Although significantly different ($p<0.05$) for Boots B and C, the difference between the measures of medial-inversion with or without the B or C boots was small (2.6 to 4.7 degrees) and not practically or functionally significant.

Following the Functionality tests involving combat activities such as marching, obstacles, advance to contact and FIBUA, participants rated the acceptance of the arch, ankle and heel support of the boots using a standard seven-point rating scale of acceptance. The results below indicate the percentage of participants rating the arch, ankle and heel support as acceptable (greater than or equal to 4 ("borderline")).

Ease and Range of Movement	User Acceptance Rating ≥ 4		
	A	B	C
Arch Support – Advance/FIBUA	91%	83%	80%
Arch Support – March & Obstacles	100%	83%	79%
Ankle Support – Advance/FIBUA	91%	83%	80%
Ankle Support – March & Obstacles	100%	83%	79%
Heel Support– Advance/FIBUA	100%	100%	73%
Heel Support– March & Obstacles	100%	100%	71%

For the A and B type boots, greater than 80% of participants indicated that the arch, ankle and heel support provided by the boot was acceptable. However, 80% or less participants indicated that the arch, ankle and heel support of the C boot was acceptable.

4.6.2 Exit Questionnaires

The Exit questionnaire results below indicate the percentage of participants rating the items related to arch, ankle and heel support as acceptable (greater than or equal to 4 ("borderline")).

Ease and Range of Movement	User Acceptance Rating ≥ 4		
	A	B	C
Arch Support	94%	88%	86%
Ankle Support	94%	82%	86%
Heel Support	100%	100%	67%

For the A and B type boots, greater than 80% of participants indicated that the boot provided acceptable arch, ankle and heel support. Although the C boot provided acceptable arch and ankle support for greater than 80% of participants, less than 80% of participants indicated that the C boot provided acceptable heel support.

4.6.3 Exit Focus Group Comments

Of all the participants that wore the A boot, a majority (85%) of participants expressed that the ankle support was adequate. Of all the participants that wore the B boot, a majority (86%) of participants expressed that the ankle support was adequate. However, 50% believed the in-service boot (when dry) provided better ankle support than the B boot. Although acceptable, the B boot could be improved by providing increased ankle support. Comments indicated that the cushioning of Boot B may compromise some of the support.

Of all the participants that wore the C boot, half (50%) believed that the removable insole was better than the A or B boot. Participants expressed that the insole was better contoured and provided better arch support. However, more than half of the participants (69%) indicated that the heel was too wide and stiff to provide adequate heel support.

4.6.4 Ease and Range of Movement Summary

Overall, the A and B boots were compliant with all of the Ease and Range of Movement Human Factors performance requirements, whereas the C boot was not compliant with requirement 5.4. Results from the Ease and Range of Movement tests indicated that none of the boots restricted plantar flexion to less than 90 degrees. The measures of dorsi-flexion with or without boots were not statistically different ($p<0.05$) for any type of boot. The measures of medial-inversion with or without boots were statistically different ($p<0.05$) for the B and C boots. Although statistically significant, the difference between the measures of medial-inversion with or without the B or C boots was small (2.6 to 4.7 degrees) and not practically or functionally significant. Results from the Functionality tests and the Exit questionnaire indicated that greater than 80% of participants indicated that the arch, ankle and heel support provided by the A and B boots was acceptable. However, 80% or less participants consistently indicated that the heel support of the C boot was acceptable. Ratings of heel and ankle support were rated less acceptable during the Functionality tests than the Exit questionnaire because the lack of support was more distinguishable during the performance of combat activities.

4.7 Physical Comfort Results

6.1 Most soldiers (>80%) shall rate the overall comfort of the boot as acceptable (i.e. ≥4).	✓	✓	✗
6.2 Following marches and task simulations, most soldiers (>80%) shall rate the physical comfort of the boot as less than "painful" (i.e. <4)	✓	✓	✗
6.3 Most soldiers (>80%) shall rate the sole cushioning of the boot as acceptable (i.e. ≥4).	✓	✓	✓
6.4 Most soldiers (>80%) shall rate the boots' resistance to causing blisters as acceptable (i.e. ≥4).	✓	✓	✗

4.7.1 Physical Comfort Tests

Following select Functionality tests (i.e. marching and obstacles) participants completed a Physical Comfort questionnaire to indicate the foot location and levels of discomfort experienced during the drills. Discomfort included contact irritation or pressure points. HF staff investigated some reports of discomfort through interviews with affected participants. The Physical Comfort questionnaire results below indicate the percentage of participants rating the physical comfort of the boot as less than 4 ["painful"] on a 5 point scale (i.e. 1=neutral, 2=slight discomfort, 3=noticeable discomfort, 4=pain, 5=extreme pain). The highest rating for any area of the foot was used as the rating for the entire foot (i.e. worst case scenario).

Physical Comfort Questionnaire	User Acceptance Rating < 4 "painful"		
	A	B	C
Session 2: Physical Comfort (entire foot)	87%	85%	58%
Session 3: Physical Comfort (entire foot)	100%	90%	71%

In both sessions 2 and 3, greater than 80% of participants indicated that the overall physical comfort of the A and B type boots was acceptable. However, less than 80% of participants indicated that the overall physical comfort of the C boot was acceptable.

Following the Functionality tests involving combat activities such as marching, obstacles, advance to contact and FIBUA, participants rated the acceptance of the physical comfort, sole cushioning and blister resistance of the boots using a standard seven-point rating scale of acceptance. The results below indicate the percentage of participants rating these items as acceptable (greater than or equal to 4 ("borderline")).

Physical Comfort	User Acceptance Rating ≥ 4		
	A	B	C
Session 2: Physical Comfort – March & Obstacles	94%	100%	80%
Session 3: Physical Comfort – March & Obstacles	100%	100%	67%
Session 3: Physical Comfort – Advance/FIBUA	100%	100%	71%
Session 2: Sole Cushioning – March & Obstacles	100%	100%	88%
Session 3: Sole Cushioning – March & Obstacles	100%	100%	93%
Session 3: Sole Cushioning – Advance/FIBUA	100%	100%	100%
Session 2: Blister Resistance – March & Obstacles	81%	85%	59%
Session 3: Blister Resistance – March & Obstacles	100%	92%	57%
Session 3: Blister Resistance – Advance/FIBUA	100%	83%	53%

For the A and B type boots, greater than 80% of participants indicated that the overall physical comfort of the boot was acceptable. However, 80% of participants or less indicated that the overall physical comfort of the C boot was acceptable.

In both sessions 2 and 3, greater than 80% of participants indicated that all the types of boots provided an acceptable level of sole cushioning.

For the A and B type boots, greater than 80% of participants, in both sessions 2 and 3, indicated that the boots provided an acceptable level of resistance against blisters. However, less than 80% of participants indicated that the C boot was acceptable for blister resistance.

4.7.2 Exit Questionnaires

The Exit questionnaire results below indicate the percentage of participants rating the items related to physical comfort as acceptable (greater than or equal to 4 ("borderline")).

Physical Comfort	User Acceptance Rating ≥ 4		
	A	B	C
Overall Rating – Physical Comfort	100%	100%	73%
Sole Cushioning	100%	100%	86%
Blister Resistance	100%	94%	52%

For the A and B type boots, greater than 80% of participants indicated that the overall physical comfort of the boot was acceptable. However, less than 80% of participants indicated that the overall physical comfort of the C boot was acceptable. Participants rated the physical comfort of various areas of the foot on the Exit Questionnaire. Features included calf, ankle, heel, instep, toes, width, sole length, & boot height. All features, with the exception of the heel and toes of boot C, were rated acceptable by more than 80% of participants.

Greater than 80% of participants indicated that all the types of boots provided an acceptable level of sole cushioning. For the A and B type boots, greater than 80% of participants indicated that the boots provided an acceptable level of resistance against blisters. However, less than 80% of participants indicated that the C boot was acceptable for blister resistance.

4.7.3 Exit Focus Group Comments

All participants that wore the A boot indicated that it provided excellent physical comfort. All participants that wore the B boot also indicated that the physical comfort was excellent. Participants that wore the C boot indicated various items that contributed to poor overall physical comfort. Some participants indicated that the toe box was too small and the heel was too wide and stiff. In addition, the stiffness of the heel construction created pressure points around the medial and lateral malleoli (ankle bones) of the foot. These contributed to the formation of blisters and poor physical comfort.

4.7.4 Physical Comfort Summary

Overall, the A and B boots were compliant with all of the Physical Comfort Human Factors performance requirements. The C boot was non-compliant with most of the Physical Comfort HF performance requirements except for requirement 6.3 related to sole cushioning.

Results from both the Physical Comfort tests and the Exit questionnaire indicated that greater than 80% of participants found the overall physical comfort of the A and B type boots was acceptable. However, less than 80% of participants indicated that the overall physical comfort of the C boot was acceptable.

Results from the Physical Comfort questionnaires indicated that following marches and task simulations, most soldiers (>80%) rated the physical comfort of the A and B boots as less than "painful." However, less than 80% of participants indicated that the physical comfort of the C boot was less then painful.

Greater than 80% of participants indicated that all the types of boots provided an acceptable level of sole cushioning.

Results from both the Functionality questionnaires and the Exit questionnaire indicated that greater than 80% of participants found the A and B boots provided an acceptable level of resistance against blisters. However, less than 80% of participants indicated that the C boot was acceptable for blister resistance.

4.8 Durability / Protection Results

7.1 Most soldiers (>80%) shall rate the overall durability as acceptable (i.e. ≥4).	✓	✓	✓
7.2 Most soldiers (>80%) shall rate the overall protection as acceptable (i.e. ≥4).	✓	✓	✓
7.3 Footwear shall be resistant to chemicals such as antifreeze, POL (Petroleum, Oil, Lubricant), battery acid, seawater, human sweat, and insect repellent (DEET).	DSSPM Testing		

4.8.1 Durability / Protection Tests

Following the Functionality tests involving combat activities such as marching, obstacles, advance to contact and FIBUA, participants rated the acceptance of the overall protection, and overall durability of the boots using a standard seven-point rating scale of acceptance. The results below indicate the percentage of participants rating these items as acceptable (greater than or equal to 4 ("borderline")).

Durability / Protection	User Acceptance Rating ≥ 4		
	A	B	C
Session 2: Overall Protection – March & Obstacles	100%	100%	100%
Session 3: Overall Protection – March & Obstacles	100%	100%	100%
Session 3: Overall Protection – Advance/FIBUA	100%	100%	100%
Session 2: Durability – March & Obstacles	100%	100%	100%
Session 3: Durability – March & Obstacles	100%	100%	100%
Session 3: Durability – Advance/FIBUA	100%	100%	100%

Greater than 80% of participants indicated that all the types of boots provided an acceptable level of overall protection and durability.

4.8.2 Boot Inspections

All boots were inspected for damage (i.e. abrasion, tears, ripped seams) and sole wear. A durability assessment form was completed by a Human Factors observer at the completion of the trial for each boot, and also during session 2 for the control group. Durability observations aside from normal wear and tear (i.e. wear of heel, toe abrasion, & minor scrapes) from both the controlled and uncontrolled trial participants are summarized below for each boot type.

Controlled Trial Participants

Boot A: Thirteen pairs of "A" boots were assessed from the controlled group. Durability observations noted the following:

- Broken pull tab (23% of participants)
- Flattened Speed Lacing restricting access of lace (8% of participants)
- Loss of Eyelet (8% of participants)
- Split of sole from boot. No water breach (31% of participants)

Boot B: Fourteen pairs of "B" boots were assessed from the controlled group. Durability observations noted the following:

- Split of sole from boot. No water breach (50% of participants)
- Broken pull tab (7% of participants)

Boot C: Nineteen pairs of "C" boots were assessed from the controlled group. Durability observations noted the following:

- Minor crack in seam where the sole meets the boot. No water breach (21% of participants)
- Loss of Eyelet (5% of participants)

Uncontrolled Trial Participants

Uncontrolled trial participants exposed their boots to twice as much wear as the participants in the controlled trial.

Boot A: Three pairs of "A" boots were assessed from the uncontrolled group. Durability observations noted the following:

- Split of sole from boot. No water breach (33% of participants)
- Gap (sole/boot) and leakage in the toes (33% of participants)

Boot B: Six pairs of "B" boots were assessed from the uncontrolled group. Durability observations noted the following:

- Split of sole from boot. No water breach (100% of participants)
- Eyelet bent over (17% of participants)

Boot C: Three pairs of "C" boots were assessed from the uncontrolled group. Durability observations noted the following:

- Minor crack in seam where the sole meets the boot. No water breach (33% of participants)

4.8.3 Exit Questionnaires

The results from the Exit questionnaires below indicate the percentage of participants rating the items related to durability and protection as acceptable (greater than or equal to 4 ("borderline")).

Durability / Protection	User Acceptance Rating ≥ 4		
	A	B	C
Sole Protection	100%	100%	95%
Overall Rating – Durability / Protection	100%	100%	95%

For all the boot types, greater than 80% of participants indicated that the boots provided acceptable sole protection and overall durability. Participants rated the durability of various boot features on the Exit Questionnaire. Features included calf padding, pull assist, upper, heel, sole, insert, tongue, tongue binding, eyelets, ankle flex notch, laces, toe cap, lace to toe (length), boot lining, interior threading, and exterior threading. All features, with the exception of the pull assist of the A boot were rated acceptable by more than 80% of participants.

4.8.4 Exit Focus Group Comments

In the focus group discussions, all participants indicated that the durability of the A and C boots was excellent. Of the participants that wore the B boot, 75% believed that the boots abraded faster than expected. Some comments suggested additional stitching may be beneficial to improve durability. However, care would need to be taken to ensure additional stitching does not contribute to additional stiffness.

Participants indicated that they had encountered some exposure to chemicals such as antifreeze, POL, battery acid, seawater (saltwater), human sweat, and insect repellent over the course of the trial period. None of the participants indicated that chemicals had compromised the functionality or protection provided by the boots.

4.8.5 Durability / Protection Summary

Overall, each of the three boot types was compliant with all the durability / protection human factors performance requirements. The participant ratings from both the Functionality questionnaires and the Exit questionnaires indicated that most soldiers (greater than 80%) rated the overall durability of all boot types as acceptable (i.e. ≥ 4). The participant ratings both the Functionality questionnaires and the Exit questionnaires also indicated that most soldiers (greater than 80%) rated the protection as acceptable (i.e. ≥ 4). None of the participants indicated that chemicals had compromised the functionality or protection provided by the boots.

4.9 Water Resistance Results

8.1 The boot must not gain more than 350 g of water during the 2 hour wetting test, and must have less than 175 g remaining after a 2 hour drying period.	✓*	✓*	✓*
8.2 Most soldiers (>80%) shall rate the through-the-boot water resistance of the boots as acceptable (i.e. ≥4).	✓	✓	✓
8.3 Most soldiers (>80%) shall rate the over-the-top water resistance of the boots as acceptable (i.e. ≥4).	✓	✓	✓

*Assessed by DCIEM

4.9.1 Water Resistance Tests

A separate study was conducted by DCIEM to assess HF performance requirement 8.1, "the boot must not gain more than 350 g of water during the 2 hour wetting test, and must have less than 175 g remaining after a 2 hour drying period. Details regarding the tests and results are provided in Annex D.

To assist water resistance, participants walked through wet ground, shallow puddles and ankle high water during their rucksack march. Water resistance and wetted boot characteristics were investigated through questionnaire ratings and participant comments.

Water Resistance	User Acceptance Rating ≥ 4		
	A	B	C
Session 2: Water Resistance– March & Obstacles	94%	100%	100%
Session 3: Water Resistance– March & Obstacles	100%	100%	100%
Session 3: Water Resistance– Advance/FIBUA	100%	100%	100%

For all the boot types, greater than 80% of participants indicated that the boots provided acceptable water resistance during combat activities.

4.9.2 Exit Questionnaires

The Exit questionnaire results below indicate the percentage of participants rating the performance as acceptable (greater than or equal to 4 ("borderline")).

Water Resistance	User Acceptance Rating ≥ 4		
	A	B	C
Drying (time required)	69%	76%	76%
Water Resistance (through the boot)	100%	100%	100%
Water Resistance (over the top of boot)	71%	82%	75%
Overall Rating – Water Resistance	94%	100%	95%

Ratings for "Water Resistance (over the top of boot)" were rated acceptable by less than 80% of participants for boots A and C. Focus group discussions (see below) were used to clarify the requirement in more detail.

4.9.3 Exit Focus Group Comments

"Water Resistance (over the top of boot)" was rated acceptable by 100% of participants for all boot types when they defined the criteria as "Resistance (but not prevention) of water entry over the top of the boot)." In their original ratings, some participants were uncertain whether entry of water into the boot was "unacceptable". Discussions with the participants indicated that water entry over the top of the boots was to be expected with any boot (without the addition of gators). However, an acceptable wet weather boot, when properly fitted, must resist entry of water during quick exposures to water over the cuff of the boot.

For those participants that used the A boot, comments indicated that the A boot dried faster than the C boot. The C boot was perceived to retain more water that tended to keep the socks wetter for a longer period of time. Comments also indicated that the A boot held its shape well when wetted and kept the feet warm even if wet (i.e. acted like a wetsuit).

For those participants that used the B boot, all participants indicated that the B boot had better water resistance than the Mark III boot. Comments indicated that the boots stretched slightly when wet, but within acceptable limits. Comments also indicated that the insoles dried very slow (required more than 48 hours to air dry), and must be removed from the boot to dry.

4.9.4 Water Resistance Summary

Overall, each of the three boot types was compliant with all the water resistance human factors performance requirements. A separate study was conducted by DCIEM to assess HF performance requirement 8.1 related to drying. The participant ratings from both the Functionality questionnaires and the Exit questionnaires indicated that most soldiers (greater than 80%) rated the overall water resistance (both through-the-boot and over-the-top) of all boot types as acceptable (i.e. ≥ 4).

4.10 Aural Detection / Appearance Results

9.1 Soldiers must perceive the footwear to be silent in use.	✓	✓	✓
9.2 By its design and appearance, the boots shall be perceived by the soldier as providing a professional military image. Most soldiers (>80%) shall rate the appearance of the boots as acceptable (i.e. ≥4).	✓	✓	✗

4.10.1 Exit Questionnaires

The results below indicate the percentage of participants rating these criteria as acceptable (greater than or equal to 4 ("borderline")).

Aural Detection / Appearance	User Acceptance Rating ≥ 4		
	A	B	C
Noise Production	94%	100%	90%
Appearance	100%	100%	76%

For all the boot types, greater than 80% of participants indicated that the boots produced an acceptable level of noise during combat activities. For the A and B boots, greater than 80% of participants indicated that the boots had an acceptable appearance. However, the C boot was rated by less than 80% of participants as providing an acceptable appearance.

4.10.2 Exit Focus Group Comments

Focus group comments indicated that all types of boots were perceived to be silent in use. No "squeeking" or unexpected noises resulted from normal use for garrison or combat activities. A majority of participants preferred the appearance of the A or B type boots rather than the C boot. Comments indicated that the C boot was unattractive due to the lip of the sole that extended around the boot. Participants indicated that the boot and the lip of the sole collected dirt, dust and mud easily, contributing to a less professional military image.

4.10.3 Aural Detection / Appearance Summary

Overall, the A and B boot types were compliant with all the aural detection / appearance human factors performance requirements. However, the C boot was non-compliant with HF performance requirement 9.2 related to appearance.

The participant ratings from the Exit questionnaires indicated that most soldiers (greater than 80%) rated the overall noise production of all boot types as acceptable (i.e. ≥ 4) and silent to use. For the A and B type boots, the Exit questionnaires indicated that most soldiers (greater than 80%) rated the appearance as acceptable (i.e. ≥ 4). However, the C boot was rated by less than 80% of participants as providing an acceptable appearance. Participants indicated that the boot and the lip of the sole collected dirt, dust and mud easily, contributing to a less professional military image.

4.11 Thermal Protection Results

10.1 The design and materials of the footwear shall provide ***thermal comfort**** to the feet (when worn with the sock system) during all operational activities conducted at temperatures ranging from –10 degrees centigrade to +10 degrees centigrade.	✓	✓	✓
10.2 Soldiers shall not rate the overall thermal comfort, on average, as cold or hot in temperatures ranging from –10 degrees centigrade to +10 degrees centigrade.	✓	✓	✓
10.3 Most soldiers (greater than 80%) shall rate the thermal comfort of the boot for its intended climatic categories as acceptable (i.e. ≥4).	✓	✓	✓
10.4 Most soldiers (greater than 80%) shall rate the sweat release (water vapour permeability) of the boot as acceptable (i.e. ≥4).	✓	✓	X

* "Thermal comfort" in this context is equivalent to most soldiers (greater than 80%) rating the thermal comfort of the boot as acceptable following select functionality tests.

4.11.1 Thermal Protection Tests

The thermal protection afforded by each boot was evaluated following select functionality tests (i.e. marching, obstacles, advance to contact and FIBUA assault). Participants completed a Thermal Comfort Questionnaire comprised of drawings of all sides and surfaces of the foot. Participants indicated the location of any heat build-up or heat loss and rated the amount of thermal discomfort using the seven point rating scale provided. Weather conditions during both Sessions 2 and 3 were overcast to partly cloudy and approximately 10°C. HF observers investigated reports of cold or hot spots through interviews with affected participants.

Following the Functionality tests involving combat activities such as marching, obstacles, advance to contact and FIBUA, participants rated the acceptance of the thermal comfort of the boots using a standard seven-point rating scale of acceptance. The results below indicate the percentage of participants rating these items as acceptable (greater than or equal to 4 ("borderline")).

Thermal Comfort	User Acceptance Rating ≥ 4		
	A	B	C
Session 2: Thermal Comfort March/Obstacles	88%	100%	94%
Session 3: Thermal Comfort March/Obstacles	100%	100%	100%
Session 3: Thermal Comfort Advance / FIBUA	100%	100%	100%

For both session 2 and 3, greater than 80% of participants rated the thermal comfort of all boot types as acceptable.

Descriptive statistics (means and standard deviations) of the Thermal Comfort questionnaire ratings are provided below. For each participant, the hottest or coldest rating for any body area was used as the value for the calculation of the mean value. Ratings on the seven point scale included the following; 1=very cold, 2=cold, 3=cool, 4=neutral, 5=warm, 6=hot, 7=very hot.

Thermal Comfort Questionnaire	A		B		C	
	mean	s.d.	mean	s.d.	Mean	s.d.
Session 2: Overall Thermal Comfort	4.6	1.1	5.2	1.0	5.5	0.9
Session 3: Overall Thermal Comfort	5.1	0.9	5.2	1.2	5.0	0.9

On average, the ratings for all boot types fell between "neutral" [4] and "hot" [6]. In session 2, 20%, 38% and 47% of participants rated an area of the A,B or C boot respectively as "hot". In session 3, 45%, 36% and 23% of participants rated an area of the A,B or C boot respectively as "hot". In either session, there were no ratings below neutral (i.e. very cold, cold or cool).

The Exit questionnaire results below indicate the percentage of participants rating the boots ability to release sweat as acceptable (greater than or equal to 4 ("borderline")).

Sweat Release	User Acceptance Rating ≥ 4		
	A	B	C
Session 2: Sweat Release March/Obstacles	81%	100%	88%
Session 3: Sweat Release March/Obstacles	100%	100%	79%
Session 3: Sweat Release Advance / FIBUA	100%	100%	87%

Greater than 80% of participants indicated that the overall sweat release of the A and B type boots was acceptable. However, less than 80% of participants rated the sweat release of the C boot acceptable during march and obstacle activities in cold and wet environmental conditions.

4.11.2 Exit Questionnaires

The Exit questionnaire results below indicate the percentage of participants rating the suitability of the boots in various climatic categories as acceptable (greater than or equal to 4 ("borderline")).

Thermal Protection	User Acceptance Rating ≥ 4		
	A	B	C
Extreme Cold (-10°C or colder)	100%	100%	83%
Cold (-10°C to 0°C)	100%	100%	95%
Cool (0°C to 10°C)	100%	100%	95%
Warm (10°C to 20°C)	94%	100%	90%
Hot (20°C or above)	82%	55%	62%
Insulation Outdoors	100%	100%	100%
Insulation Indoors	100%	88%	90%
Overall Rating – Thermal Protection	100%	100%	95%

Extreme Cold conditions were experienced by approximately 47% of participants using the A boot, 59% of participants using the B boot, and 29% of participants using the C boot. Cold conditions were experienced by more than 90% of participants in all boot types. Hot conditions were experienced by approximately 65% of participants using the A boot, 65% of participants using the B boot, and 62% of participants using the C boot.

The Exit questionnaire results below indicate the percentage of participants rating the boots ability to release sweat as acceptable (greater than or equal to 4 ("borderline")).

Sweat Release	User Acceptance Rating ≥ 4		
	A	B	C
Sweat Release	94%	100%	77%

Greater than 80% of participants indicated that the overall sweat release of the A and B type boots was acceptable. However, less than 80% of participants rated the overall sweat release of the C boot acceptable.

4.11.3 Exit Focus Group Comments

All participants agreed that the A and B boots are well suited for temperatures between -10°C and +10°C. Comments indicated the A and B boots were a bit warm in garrison. Other comments indicated that toes get slightly cold below -15°C with the A and B boots. Participants believed the A and B boots were warmer than the C boot. All participants agreed that all the bid boots provided better thermal protection than the current in-service boot.

4.11.4 Thermal Comfort Summary

Overall, the A and B boots were compliant with all of the Thermal Comfort Human Factors performance requirements. The C boot was compliant with all the Thermal Comfort HF performance requirements except for requirement 10.4 related to sweat release.

Results from both the Functionality questionnaires and the Exit questionnaire indicated that greater than 80% of participants found the overall thermal comfort of all the boot types was acceptable. The design and materials of the footwear provided acceptable thermal comfort to the feet during all operational activities conducted at temperatures ranging from –10 °C to +10 °C.

Results from the Thermal Comfort questionnaires indicated that following marches and task simulations, soldiers did not rate the overall thermal comfort of all types of boots as cold or hot in temperatures ranging from –10 °C to +10 °C.

Results from the Exit questionnaires indicated that greater than 80% of soldiers rated the thermal comfort of the boot for its intended climatic categories (i.e. Cold, Cool, and Warm) as acceptable.

4.12 User Maintainability Results

	[redacted]		
11.1 Most soldiers (≥80%) shall rate the required boot care as acceptable (i.e. ≥4).	✓	✓	✓
11.2 The clothing system must be maintainable and repairable by an individual without special tools under normal operational conditions.	DSSPM Test		

4.12.1 Exit Questionnaires

The Exit questionnaire results below indicate the percentage of participants rating the items related to maintainability as acceptable (greater than or equal to 4 ("borderline")).

User Maintainability	User Acceptance Rating ≥ 4		
	A	B	C
Cleaning	100%	94%	90%
Brushing	100%	94%	90%
Overall Rating - Maintainability	100%	94%	91%

For all the boot types, greater than 80% of participants indicated that the boots were acceptable for cleaning, brushing, and overall maintainability. Less than 20% of participants required some repairs to their boots (A=12%, B=18%, C=10%). Repairs were minor and were not detrimental to the overall functionality of the boots.

4.12.2 Exit Focus Group Comments

For all boot types, none of the participants indicated problems with cleaning, brushing or maintaining the boot over the trial period. Based on the use of the boots over the trial period, all participants indicated that the clothing system could be maintainable and repairable without special tools.

4.12.3 User Maintainability Summary

Overall, all the boot types were compliant with all of the user maintainability Human Factors performance requirements. For all the boot types, greater than 80% of participants indicated that the boots were acceptable for cleaning, brushing, and overall maintainability. Based on the use of the boots over the trial period, all participants indicated that the clothing system could be maintainable and repairable without special tools.

4.13 Weight Results

12.1 This criterion is not intended to be a pass-fail criterion, but rather as input to the "Value for Money" calculation which will be performed if more than one bidder is found to be compliant. All other criteria being equal, a lighter boot will be chosen over a heavier boot.	Not Applicable

4.13.1 Exit Questionnaires

At the completion of the three-month trial period, participants were required to rate the acceptability of the lightweight characteristics of each boot submission. The Exit questionnaire results below indicate the percentage of participants rating the items related to weight as acceptable (greater than or equal to 4 ("borderline")).

	User Acceptance Rating ≥ 4		
Weight	A	B	C
Weight (for stowage)	100%	100%	81%
Weight (for comfort)	100%	100%	71%

For the A and B boots, 100% of participants indicated that the boots had an acceptable weight for comfort. The C boot was rated by 71% and 81% of participants as providing an acceptable weight for stowage and comfort respectively.

4.13.2 Exit Focus Group Comments

For boot types A and B, none of the participants indicated issues related to the weight of the boot. For the C boot, 69% of participants indicated that they perceived the C boot to be noticeably heavier (when dry).

4.13.3 Weight Summary

This criterion is not intended to be a pass-fail criterion, but rather as input to the "Value for Money" calculation which will be performed if more than one bidder is found to be compliant. All other criteria being equal, a lighter boot will be chosen over a heavier boot.

4.14 Boot Comparison and Overall Impressions

Boot comparison questionnaires were completed by participants prior to the exit focus group discussions. Participants were asked to compare the two boot types over a range of boot criteria and features. Participants also provided an "overall impression" comparison. These results are provided below.

AB "Overall Impression" Comparison (n=6).

- 3 (50%) believed that A was better than B
- 1 (17%) believed that B was better than A
- 2 (33%) believed that A and B were alike.

AC "Overall Impression" Comparison (n=9).

- 9 (100%) believed that A was better than C
- 0 believed that C was better than A
- 0 believed that A and C were alike.

BC "Overall Impression" Comparison (n=9).

- 6 (67%) believed that B was better than C
- 3 (33%) believed that C was better than B
- 0 believed that B and C were alike.

Overall, the A boot was preferred by a majority of the participants. Of all the participants that wore the A boot, 50% believed that the A boot was better than the B boot, and all participants believed that the A boot was better than the C boot. Participants that did not wear the A boot preferred the B boot over the C boot.

4.15 Value For Money

Mean (average) ratings of acceptance for 14 boot criteria, based on the seven-point rating scale of acceptance, are provided in Table 2 below. These values have been provided for use in the Value for Money Equation.

Table 2: Mean Ratings of Acceptability.

5.9	6.2	6.0
5.9	6.2	4.8
6.4	6.4	4.4
5.3	5.6	4.8
6.1	6.1	5.2
6.2	6.1	6.1
5.9	6.1	5.1
6.3	6.2	5.1
4.9	5.0	4.8
6.2	5.9	5.6
5.8	6.1	4.4
6.1	6.5	4.8
5.9	5.9	5.5
6.2	6.4	5.3

5. Discussion

A battery of controlled and uncontrolled scientific Human Factors performance tests were conducted at CFB Petawawa as part of a bid evaluation of Wet Weather Boot bid contenders. Three different submissions were tested to determine if they were compliant with the HF performance specifications developed in previous studies (Reference A).

The participants in the controlled trial took part in an array of tests to assess the HF performance criteria. The performance specifications evaluated included Accessibility, Compatibility, Fit and Adjustment, Functionality, Ease and Range of Motion, Physical Comfort, Durability/Protection, Water Resistance, Detection/Appearance, Thermal Protection, User Maintainability, & Weight. Issues associated with bid boot compliance or non-compliance with HF performance specifications are discussed below.

5.1 Bid Boot Compliance

A summary of compliance with the HF Performance Specifications is provided in Table 3 below.

Table 3: Summary of Compliance with HF Performance Specifications

✓ = Compliant X = Non-Compliant

1.1 Most soldiers (greater than 80%) shall rate the doffing and donning of the boot as better than acceptable (i.e. >4)	✓	✓	✓
1.2 Donning the boots with bare hands shall be accomplished within 40 sec.	✓	✓	✓
1.3 Doffing the boots with bare hands shall be accomplished within 20 sec.	✓	✓	✓
2.1 The boots shall not interfere with the operation of clothing, vehicles, equipment, or weapon systems.	✓	✓	✓
2.2 Most soldiers (>80 %) shall rate the overall compatibility as acceptable (i.e. ≥4)	✓	✓	✓
2.3 Most soldiers (>80%) shall rate the compatibility with individual items as acceptable (i.e. ≥4).	✓	✓	✓
3.1 Fit shall accommodate at least 95% of the CF LF population (males and females)	✓	✓	✓
3.2 Most participants (>80%) shall rate the overall adjustment of the boots as acceptable (i.e. ≥4).	✓	✓	✓
3.3 Most participants (>80%) shall rate the boots as broken-in within two weeks of issue.	✓	✓	X
4.1 The individual must be able to wear the boots continuously under normal operational conditions and activities with minimal reduction in operational effectiveness.	✓	✓	✓
4.2 Most soldiers (>80%) shall rate the overall functionality as acceptable (i.e. ≥4).	✓	✓	X
4.3 Most soldiers (>80%) shall rate the functionality with individual activities as acceptable (i.e. ≥4).	✓	✓	X

5.1 The boots shall not restrict plantar flexion to less than 90 degrees.	✓	✓	✓
5.2 The boots shall not restrict dorsi-flexion significantly from the barefooted condition.	✓	✓	✓
5.3 The boots shall not restrict ankle medial-inversion significantly from the barehanded condition.	✓	✓	✓
5.4 Most soldiers (>80%) shall rate the arch, ankle, and heel support as acceptable (i.e. ≥4).	✓	✓	X
6.1 Most soldiers (>80%) shall rate the overall comfort of the boot as acceptable (i.e. ≥4).	✓	✓	X
6.2 Following marches and task simulations, most soldiers (>80%) shall rate the physical comfort of the boot as less than "painful" (i.e. <4)	✓	✓	X
6.3 Most soldiers (>80%) shall rate the sole cushioning of the boot as acceptable (i.e. ≥4).	✓	✓	✓
6.4 Most soldiers (>80%) shall rate the boots' resistance to causing blisters as acceptable (i.e. ≥4).	✓	✓	X
7.1 Most soldiers (>80%) shall rate the overall durability as acceptable (i.e. ≥4).	✓	✓	✓
7.2 Most soldiers (>80%) shall rate the overall protection as acceptable (i.e. ≥4).	✓	✓	✓
7.3 Footwear shall be resistant to chemicals such as antifreeze, POL (Petroleum, Oil, Lubricant), battery acid, seawater, human sweat, and insect repellent (DEET).	DSSPM Test		
8.1 The boot must not gain more than 350 g of water during the 2 hour wetting test, and must have less than 175 g remaining after a 2 hour drying period.	✓	✓	✓
8.2 Most soldiers (>80%) shall rate the through-the-boot water resistance of the boots as acceptable (i.e. ≥4).	✓	✓	✓
8.3 Most soldiers (>80%) shall rate the over-the-top water resistance of the boots as acceptable (i.e. ≥4).	✓	✓	✓
9.1 Soldiers must perceive the footwear to be silent in use.	✓	✓	✓
9.2 By its design and appearance, the boots shall be perceived by the soldier as providing a professional military image. Most soldiers (>80%) shall rate the appearance of the boots as acceptable (i.e. ≥4).	✓	✓	X
10.1 The design and materials of the footwear shall provide thermal comfort to the feet (when worn with the sock system) during all operational activities conducted at temperatures ranging from –10 degrees centigrade to +10 degrees centigrade.	✓	✓	✓
10.2 Soldiers shall not rate the overall thermal comfort, on average, as cold or hot in temperatures ranging from –10 degrees centigrade to +10 degrees centigrade.	✓	✓	✓
10.3 Most soldiers (greater than 80%) shall rate the thermal comfort of the boot for its intended climatic categories as acceptable (i.e. ≥4).	✓	✓	✓
10.4 Most soldiers (greater than 80%) shall rate the sweat release (water vapour permeability) of the boot as acceptable (i.e. ≥4).	✓	✓	X

[redacted]			
11.1 Most soldiers (≥80%) shall rate the required boot care as acceptable (i.e. ≥4).	✓	✓	✓
11.2 The clothing system must be maintainable and repairable by an individual without special tools under normal operational conditions.	DSSPM Test		
[redacted]			
12.1 This criterion is not intended to be a pass-fail criterion, but rather as input to the "Value for Money" calculation which will be performed if more than one bidder is found to be compliant. All other criteria being equal, a lighter boot will be chosen over a heavier boot.	Not Applicable		

5.2 Conclusion

Overall, both the A and B boots were compliant with all eleven (not including weight) Human Factors Performance Criteria. However, the C boot was non-compliant with six of the eleven Human Factors Performance Criteria. The C boot was compliant with the accessibility, compatibility, durability / protection, water resistance, and user maintainability requirements, but was non-compliant with the fit and adjustment, functionality, ease and range of movement, physical comfort, aural detection / appearance, and thermal protection requirements.

ANNEX A:
Questionnaires

ANNEX A: Questionnaires

i. **Initial Fit Questionnaire**
ii. **WWB Functionality Questionnaire: March & Obstacles**
iii. **Physical Comfort Questionnaire**
iv. **Thermal Comfort Questionnaire**
v. **Session 2 Questionnaire**
vi. **WWB Functionality Questionnaire: FIBUA**
vii. **WWB Functionality Questionnaire: March & Obstacles**
viii. **Durability Questionnaire**
ix. **WWB Comparison Questionnaire**
x. **WWB Exit Questionnaire**

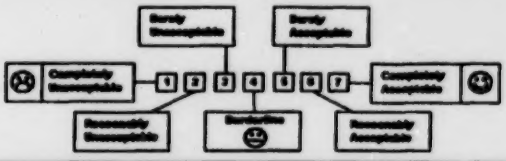
SESSION 2

WWB Session Questionnaire

PARTICIPANT NUMBER : _____

NAME : _____

BOOT: A☐ B☐ C☐

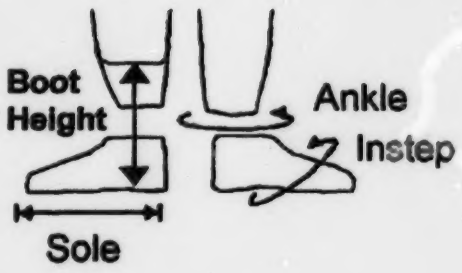


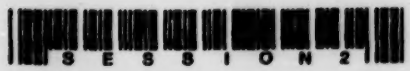
Section A: Specific Features

1. Calf Padding	OOOOOOO	OOOOOOO
2. Pull Assist	OOOOOOO	OOOOOOO
3. Upper	OOOOOOO	OOOOOOO
4. Heel	OOOOOOO	OOOOOOO
5. Sole	OOOOOOO	OOOOOOO
6. Insert	OOOOOOO	OOOOOOO
7. Tongue	OOOOOOO	OOOOOOO
8. Tongue Binding	OOOOOOO	OOOOOOO
9. Eyelets	OOOOOOO	OOOOOOO
10. Ankle Flex Notch	OOOOOOO	OOOOOOO
11. Laces	OOOOOOO	OOOOOOO
12. Toe Cap	OOOOOOO	OOOOOOO
13. Lace to Toe (Length)	OOOOOOO	OOOOOOO
14. Boot Lining	OOOOOOO	OOOOOOO
15. Interior Threading	OOOOOOO	OOOOOOO
16. Exterior Threading	OOOOOOO	OOOOOOO

Section B: Comfort and Fit

Calf	OOOOOOO	O	O	O
Ankle	OOOOOOO	O	O	O
Heel	OOOOOOO	O	O	O
Instep	OOOOOOO	O	O	O
Toes	OOOOOOO	O	O	O
Width	OOOOOOO	O	O	O
Sole Length	OOOOOOO	O	O	O
Boot Height	OOOOOOO	O	O	O





WWB Session Questionnaire

Section C: Whole Item

Walking	O	O	O	OOOOOOO	Cleaning	O	O	O	OOOOOOO
Running	O	O	O	OOOOOOO	Drying (time required)	O	O	O	OOOOOOO
Marching	O	O	O	OOOOOOO	Repairs	O	O	O	OOOOOOO
Crawling	O	O	O	OOOOOOO	Brushing	O	O	O	OOOOOOO
Climbing	O	O	O	OOOOOOO	Instructions	O	O	O	OOOOOOO
Hill Climbing	O	O	O	OOOOOOO					
Stream Fording	O	O	O	OOOOOOO	Extreme Cold -10°C or colder	O	O	O	OOOOOOO
Digging	O	O	O	OOOOOOO	Cold -10°C to 0°C	O	O	O	OOOOOOO
Obstacles	O	O	O	OOOOOOO	Cool 0°C to 10°C	O	O	O	OOOOOOO
Fire and Movement	O	O	O	OOOOOOO	Warm 10°C to 20°C	O	O	O	OOOOOOO
Parachuting	O	O	O	OOOOOOO	Hot 20°C or above	O	O	O	OOOOOOO
Rappelling	O	O	O	OOOOOOO	Icy ground	O	O	O	OOOOOOO
FIBUA	O	O	O	OOOOOOO	Snow	O	O	O	OOOOOOO
Garrison Activities	O	O	O	OOOOOOO	Slush	O	O	O	OOOOOOO
Aircraft Exit / Entry	O	O	O	OOOOOOO	Rain	O	O	O	OOOOOOO
Vehicle Exit / Entry	O	O	O	OOOOOOO	Shallow Water	O	O	O	OOOOOOO
Vehicle Operation	O	O	O	OOOOOOO	Wet Brush	O	O	O	OOOOOOO
					Wet Grass	O	O	O	OOOOOOO
Combat Trousers	O	O	O	OOOOOOO	Mud	O	O	O	OOOOOOO
IECS fleece pants	O	O	O	OOOOOOO	Sand	O	O	O	OOOOOOO
IECS Ltwt. Trousers	O	O	O	OOOOOOO	Asphalt	O	O	O	OOOOOOO
IECS insulated bib	O	O	O	OOOOOOO	Gravel	O	O	O	OOOOOOO
NBC IPE coveralls	O	O	O	OOOOOOO	Rocky Ground	O	O	O	OOOOOOO
CVC bib pants	O	O	O	OOOOOOO	Wind	O	O	O	OOOOOOO
Wind pants	O	O	O	OOOOOOO	Traction Wet	O	O	O	OOOOOOO
Rain pants	O	O	O	OOOOOOO	Traction Dry	O	O	O	OOOOOOO
Arctic Whites	O	O	O	OOOOOOO		O	O	O	OOOOOOO
Combat overboots	O	O	O	OOOOOOO		O	O	O	OOOOOOO
NBC overboots	O	O	O	OOOOOOO		O	O	O	OOOOOOO
Liner Socks	O	O	O	OOOOOOO		O	O	O	OOOOOOO
J.S. Marine Socks	O	O	O	OOOOOOO		O	O	O	OOOOOOO
Norwegian Sock	O	O	O	OOOOOOO		O	O	O	OOOOOOO
Grey Wool Socks	O	O	O	OOOOOOO		O	O	O	OOOOOOO

SESSION 2

WWB Session Questionnaire

Section C: Whole Item (continued)

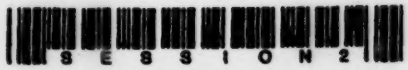
Sole Protection	☺ ☺ ☺ ☺ ☺ ☺ ☹	Putting on	☺ ☺ ☺ ☺ ☺ ☺ ☹	Noise Production	☺ ☺ ☺ ☺ ☺ ☺ ☹
Sole Cushioning	☺ ☺ ☺ ☺ ☺ ☺ ☹	Adjusting fit	☺ ☺ ☺ ☺ ☺ ☺ ☹	Odour Resistance	☺ ☺ ☺ ☺ ☺ ☺ ☹
Blister Resistance	☺ ☺ ☺ ☺ ☺ ☺ ☹	Taking off	☺ ☺ ☺ ☺ ☺ ☺ ☹	Weight (for stowage)	☺ ☺ ☺ ☺ ☺ ☺ ☹
Weight (for comfort)	☺ ☺ ☺ ☺ ☺ ☺ ☹	Lacing	☺ ☺ ☺ ☺ ☺ ☺ ☹	Water Resistance (through the boot)	☺ ☺ ☺ ☺ ☺ ☺ ☹
Insulation Outdoors	☺ ☺ ☺ ☺ ☺ ☺ ☹	[redacted]		Water Resistance (over the boot)	☺ ☺ ☺ ☺ ☺ ☺ ☹
Insulation Indoors	☺ ☺ ☺ ☺ ☺ ☺ ☹	Arch Support	☺ ☺ ☺ ☺ ☺ ☺ ☹	Time to Break In	☺ ☺ ☺ ☺ ☺ ☺ ☹
Sweat Release	☺ ☺ ☺ ☺ ☺ ☺ ☹	Ankle Support	☺ ☺ ☺ ☺ ☺ ☺ ☹	Appearance	☺ ☺ ☺ ☺ ☺ ☺ ☹
	☺ ☺ ☺ ☺ ☺ ☺ ☹	Heel Support	☺ ☺ ☺ ☺ ☺ ☺ ☹		☺ ☺ ☺ ☺ ☺ ☺ ☹

Time Required to Break In the Boots = _____ **days**

Percentage of Use = _____ **%**
(Indicate the percentage of time that you used the boot over the trial period compared to other boot types)

Section D: Overall Ratings

	Acceptability ☺ 😐 ☹
Compatibility : Rate the overall compatibility with clothing, equipment, and vehicles.	☺ ☺ ☺ ☺ ☺ ☺ ☹
Fit : Rate the extent to which you can achieve a suitable fit with the boots.	☺ ☺ ☺ ☺ ☺ ☺ ☹
Adjustability : Rate the adjustments of the boots to achieve an acceptable fit.	☺ ☺ ☺ ☺ ☺ ☺ ☹
Accessibility : Rate the relative ease with which the boots can be donned or doffed.	☺ ☺ ☺ ☺ ☺ ☺ ☹
Functionality : Rate the degree to which the boots affect your performance of tasks.	☺ ☺ ☺ ☺ ☺ ☺ ☹
Ease and Range of Movement : Rate the degree to which the boots let you perform movements throughout their range of motion.	☺ ☺ ☺ ☺ ☺ ☺ ☹
Physical Comfort : Rate the degree to which the boots contribute to comfort.	☺ ☺ ☺ ☺ ☺ ☺ ☹
Durability / Protection: Rate the degree to which the boots resist wear and tear and guards the foot from environmental factors.	☺ ☺ ☺ ☺ ☺ ☺ ☹
Thermal Protection : Rate the degree to which the boots contribute to heat gain or foot cooling for its intended climatic category (-10°C to +20°C, dry or wet).	☺ ☺ ☺ ☺ ☺ ☺ ☹
Water Resistance : Rate the degree to which the boot repels water and prevents moisture from reaching the foot.	☺ ☺ ☺ ☺ ☺ ☺ ☹
Maintainability : Rate the ease and effectiveness of minor boot cleaning and repair.	☺ ☺ ☺ ☺ ☺ ☺ ☹



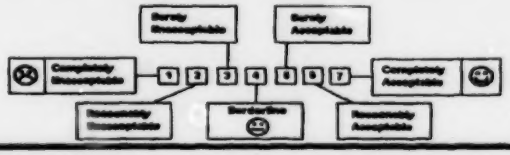
Section E: Comments

WWB 3

WWB Functionality Questionnaire: FIBUA

NAME : _____

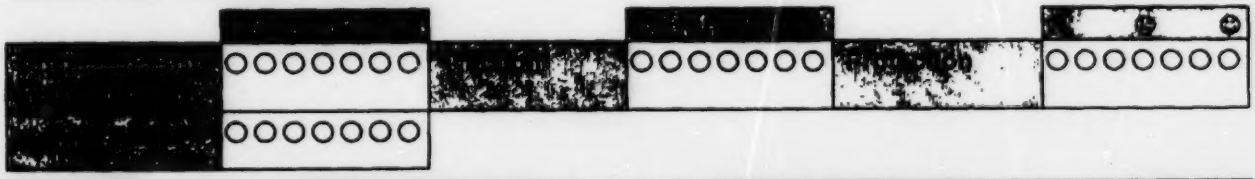
BOOT: A☐ B☐ C☐



Section A: Functionality

Walking	○○○○○○○	Mud	○○○○○○○	Cold (Insulation)	○○○○○○○
Running	○○○○○○○	Sand	○○○○○○○	Water Resistance	○○○○○○○
Jumping	○○○○○○○	Dry Asphalt	○○○○○○○	Durability	○○○○○○○
Climbing	○○○○○○○	Wet Asphalt	○○○○○○○	Sole Protection	○○○○○○○
Crawling	○○○○○○○	Rocky Ground	○○○○○○○	Arch Support	○○○○○○○
Advance to Contact	○○○○○○○	Wet Rocks	○○○○○○○	Ankle Support	○○○○○○○
Fire and Movement	○○○○○○○	Gravel	○○○○○○○	Heel Support	○○○○○○○
Traverse Ground	○○○○○○○	Dry Grass	○○○○○○○		
Gain FIBUA Access	○○○○○○○	Wet Grass	○○○○○○○	Thermal Comfort	○○○○○○○
Access Mouseholes	○○○○○○○	Shallow Water	○○○○○○○	Physical Comfort	○○○○○○○
Climb/Descend Stairs	○○○○○○○	Brush	○○○○○○○	Ease of Movement	○○○○○○○
Room Clearance	○○○○○○○	Icy Ground	○○○○○○○	Range of Movement	○○○○○○○
	○○○○○○○	Snow	○○○○○○○	Sole Cushioning	○○○○○○○
	○○○○○○○	Slush	○○○○○○○	Weight	○○○○○○○
	○○○○○○○	Traction (wet)	○○○○○○○	Sweat Release	○○○○○○○
	○○○○○○○	Traction (dry)	○○○○○○○	Blister Resistance	○○○○○○○

Section B: Overall Ratings

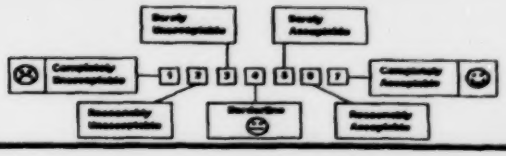


Section C: Comments (use back of page if required)

WWB Functionality Questionnaire: March/Obstacles

NAME : _____

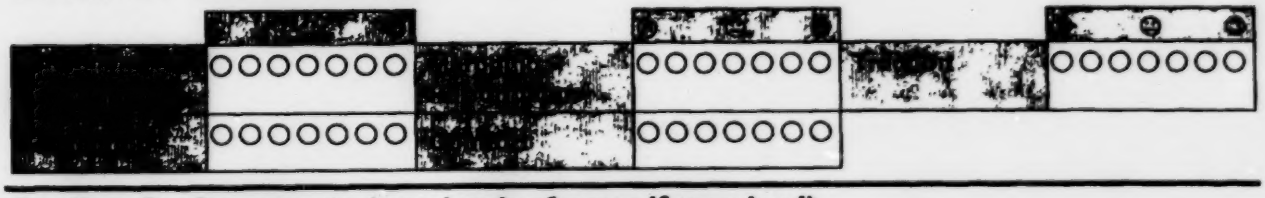
BOOT: A☐ B☐ C☐



Section A: Functionality

Walking	○○○○○○○	Mud	○○○○○○○	Cold (Insulation)	○○○○○○○
Running	○○○○○○○	Sand	○○○○○○○	Water Resistance	○○○○○○○
Jumping	○○○○○○○	Dry Asphalt	○○○○○○○	Durability	○○○○○○○
Climbing	○○○○○○○	Wet Asphalt	○○○○○○○	Sole Protection	○○○○○○○
Crawling	○○○○○○○	Rocky Ground	○○○○○○○	Arch Support	○○○○○○○
Marching	○○○○○○○	Wet Rocks	○○○○○○○	Ankle Support	○○○○○○○
Marching (with Rucksack)	○○○○○○○	Gravel	○○○○○○○	Heel Support	○○○○○○○
Steps	○○○○○○○	Dry Grass	○○○○○○○		
Low Wall	○○○○○○○	Wet Grass	○○○○○○○	Thermal Comfort	○○○○○○○
High Wall	○○○○○○○	Shallow Water	○○○○○○○	Physical Comfort	○○○○○○○
Three Rung Ladder	○○○○○○○	Brush	○○○○○○○	Ease of Movement	○○○○○○○
Low Over & Under	○○○○○○○	Icy Ground	○○○○○○○	Range of Movement	○○○○○○○
High Over & Under	○○○○○○○	Snow	○○○○○○○	Sole Cushioning	○○○○○○○
Ramp and Pit	○○○○○○○	Slush	○○○○○○○	Weight	○○○○○○○
High Ramp with Rope	○○○○○○○	Traction (wet)	○○○○○○○	Sweat Release	○○○○○○○
Maze	○○○○○○○	Traction (dry)	○○○○○○○	Blister Resistance	○○○○○○○

Section B: Overall Ratings



Section C: Comments (use back of page if required)

Cold Wet Weather Boot

Durability Questionnaire

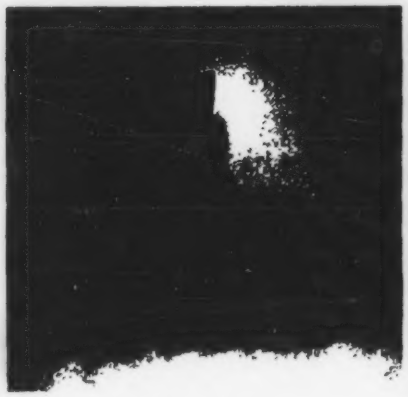
PERSONAL DATA

Clearly print your Number, Name and check the Boot Type in the boxes provided.

NAME | | | | | | | | | | | | |

BOOT TYPE A ☐ B ☐ C ☐

Note any sole delamination, cracks and tears in soles, abrasions, sole wear characteristics, failure of seams/components, punctures, burns, chemical/fuel damage, fading and discolouring.



Exposure to ...	Antifreeze ○ Petroleum / Oil / Lubricant ○ Battery Acid ○ Salt Water ○ Sweat ○ Insect Repellent ○	
Overall Durability	○○○○○○○	
Overall Ease of Care	○○○○○○○	

WWB Comparisons

NAME : _____

Fit	O	O	O	O	O	
Physical Comfort	O	O	O	O	O	
Boot Height	O	O	O	O	O	
Durability	O	O	O	O	O	
Time to Break-in	O	O	O	O	O	
Insulation Outdoors	O	O	O	O	O	
Insulation Indoors	O	O	O	O	O	
Thermal Comfort	O	O	O	O	O	
Traction	O	O	O	O	O	
Foot Support	O	O	O	O	O	
Maintainability	O	O	O	O	O	
Don & Doff	O	O	O	O	O	
FIBUA Performance	O	O	O	O	O	
Marching	O	O	O	O	O	
Obstacle Performance	O	O	O	O	O	
Appearance	O	O	O	O	O	
Water Resistance	O	O	O	O	O	
Sweat Release	O	O	O	O	O	
Compatibility-Vehicles	O	O	O	O	O	
Compatibility-Clothing & Equip.	O	O	O	O	O	
Weight Dry	O	O	O	O	O	
Weight Wet	O	O	O	O	O	

WWB Comparisons

	[redacted]					
Drying Time	O	O	O	O	O	
Stowage	O	O	O	O	O	
Cold Weather Use	O	O	O	O	O	
Cool Weather Use	O	O	O	O	O	
Warm Weather Use	O	O	O	O	O	
Wet Weather Use	O	O	O	O	O	
Protection	O	O	O	O	O	
Range of Motion	O	O	O	O	O	
Tread Clogging	O	O	O	O	O	
Boot Stretching	O	O	O	O	O	
Overall Impression	O	O	O	O	O	

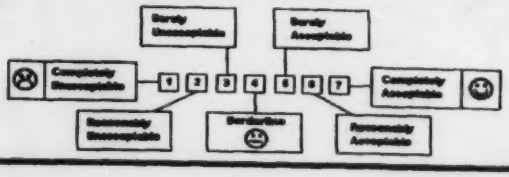
Additional Comments

WWB Exit Questionnaire

NAME : _____

UNIT & MOC : _____

BOOT: A☐ B☐ C☐

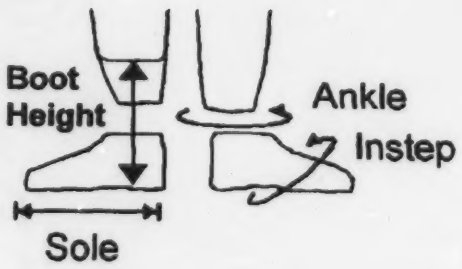


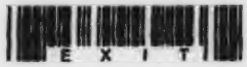
Section A: Specific Features

1. Calf Padding	OOOOOOO	OOOOOOO
2. Pull Assist	OOOOOOO	OOOOOOO
3. Upper	OOOOOOO	OOOOOOO
4. Heel	OOOOOOO	OOOOOOO
5. Sole	OOOOOOO	OOOOOOO
6. Insert	OOOOOOO	OOOOOOO
7. Tongue	OOOOOOO	OOOOOOO
8. Tongue Binding	OOOOOOO	OOOOOOO
9. Eyelets	OOOOOOO	OOOOOOO
10. Ankle Flex Notch	OOOOOOO	OOOOOOO
11. Laces	OOOOOOO	OOOOOOO
12. Toe Cap	OOOOOOO	OOOOOOO
13. Lace to Toe (Length)	OOOOOOO	OOOOOOO
14. Boot Lining	OOOOOOO	OOOOOOO
15. Interior Threading	OOOOOOO	OOOOOOO
16. Exterior Threading	OOOOOOO	OOOOOOO

Section B: Comfort and Fit

Calf	OOOOOOO	O	O	O
Ankle	OOOOOOO	O	O	O
Heel	OOOOOOO	O	O	O
Instep	OOOOOOO	O	O	O
Toes	OOOOOOO	O	O	O
Width	OOOOOOO	O	O	O
Sole Length	OOOOOOO	O	O	O
Boot Height	OOOOOOO	O	O	O





WWB Exit Questionnaire

Section C: Whole Item

Walking	O	O	O	OOOOOOO	Cleaning	O	O	O	OOOOOOC
Running	O	O	O	OOOOOOO	Drying (time required)	O	O	O	OOOOOOC
Marching	O	O	O	OOOOOOO	Repairs	O	O	O	OOOOOOO
Crawling	O	O	O	OOOOOOO	Brushing	O	O	O	OOOOOOO
Climbing	O	O	O	OOOOOOO	Instructions	O	O	O	OOOOOOO
Hill Climbing	O	O	O	OOOOOOO					
Stream Fording	O	O	O	OOOOOOO	Extreme Cold -10°C or colder	O	O	O	OOOOOOO
Digging	O	O	O	OOOOOOO	Cold -10°C to 0°C	O	O	O	OOOOOOO
Obstacles	O	O	O	OOOOOOO	Cool 0°C to 10°C	O	O	O	OOOOOOO
Fire and Movement	O	O	O	OOOOOOO	Warm 10°C to 20°C	O	O	O	OOOOOOO
Parachuting	O	O	O	OOOOOOO	Hot 20°C or above	O	O	O	OOOOOOO
Rappelling	O	O	O	OOOOOOO	Icy ground	O	O	O	OOOOOOO
FIBUA	O	O	O	OOOOOOO	Snow	O	O	O	OOOOOOO
Garrison Activities	O	O	O	OOOOOOO	Slush	O	O	O	OOOOOOO
Aircraft Exit / Entry	O	O	O	OOOOOOO	Rain	O	O	O	OOOOOOO
Vehicle Exit / Entry	O	O	O	OOOOOOO	Shallow Water	O	O	O	OOOOOOO
Vehicle Operation	O	O	O	OOOOOOO	Wet Brush	O	O	O	OOOOOOO
					Wet Grass	O	O	O	OOOOOOO
Combat Trousers	O	O	O	OOOOOOO	Mud	O	O	O	OOOOOOO
IECS fleece pants	O	O	O	OOOOOOO	Sand	O	O	O	OOOOOOO
IECS Ltwt. Trousers	O	O	O	OOOOOOO	Asphalt	O	O	O	OOOOOOO
IECS insulated bib	O	O	O	OOOOOOO	Gravel	O	O	O	OOOOOOO
NBC IPE coveralls	O	O	O	OOOOOOO	Rocky Ground	O	O	O	OOOOOOO
CVC bib pants	O	O	O	OOOOOOO	Wind	O	O	O	OOOOOOO
Wind pants	O	O	O	OOOOOOO	Traction Wet	O	O	O	OOOOOOO
Rain pants	O	O	O	OOOOOOO	Traction Dry	O	O	O	OOOOOOO
Arctic Whites	O	O	O	OOOOOOO		O	O	O	OOOOOOO
Combat overboots	O	O	O	OOOOOOO		O	O	O	OOOOOOO
NBC overboots	O	O	O	OOOOOOO		O	O	O	OOOOOOO
Liner Socks	O	O	O	OOOOOOO		O	O	O	OOOOOOO
U.S. Marine Socks	O	O	O	OOOOOOO		O	O	O	OOOOOOO
Norwegian Sock	O	O	O	OOOOOOO		O	O	O	OOOOOOO
Grey Wool Socks	O	O	O	OOOOOOO		O	O	O	OOOOOOO

WWB Exit Questionnaire

Section C: Whole Item (continued)

Sole Protection	○○○○○○○	Putting on	○○○○○○○	Noise	○○○○○○○
Sole Cushioning	○○○○○○○	Adjusting fit	○○○○○○○	Odour Resistance	○○○○○○○
Blister Resistance	○○○○○○○	Taking off	○○○○○○○	Weight (for stowage)	○○○○○○○
Weight (for comfort)	○○○○○○○	Lacing	○○○○○○○	Water Resistance (through the boot)	○○○○○○○
Insulation Outdoors	○○○○○○○			Water Resistance (over the top of boot)	○○○○○○○
Insulation Indoors	○○○○○○○	Arch Support	○○○○○○○	Time to Break In	○○○○○○○
Sweat Release	○○○○○○○	Ankle Support	○○○○○○○	Appearance	○○○○○○○
	○○○○○○○	Heel Support	○○○○○○○		○○○○○○○

Percentage of Use = _____ **%**
(Indicate the percentage of time that you used the boot over the trial period compared to other boot types)

Section D: Overall Ratings

	Acceptability ☹ 😐 ☺
Compatibility : Rate the overall compatibility with clothing, equipment, and vehicles.	○○○○○○○
Fit : Rate the extent to which you can achieve a suitable fit with the boots.	○○○○○○○
Adjustability : Rate the adjustments of the boots to achieve an acceptable fit.	○○○○○○○
Accessibility : Rate the relative ease with which the boots can be donned or doffed.	○○○○○○○
Functionality : Rate the degree to which the boots affect your performance of tasks.	○○○○○○○
Ease and Range of Movement : Rate the degree to which the boots let you perform movements throughout their range of motion.	○○○○○○○
Physical Comfort : Rate the degree to which the boots contribute to comfort.	○○○○○○○
Durability / Protection: Rate the degree to which the boots resist wear and tear and guards the foot from environmental factors.	○○○○○○○
Thermal Protection : Rate the degree to which the boots contribute to heat gain or foot cooling for its intended climatic category (-10°C to +20°C, dry or wet).	○○○○○○○
Water Resistance : Rate the degree to which the boot repels water and prevents moisture from reaching the foot.	○○○○○○○
Maintainability : Rate the ease and effectiveness of minor boot cleaning and repair.	○○○○○○○

Section E: Comments

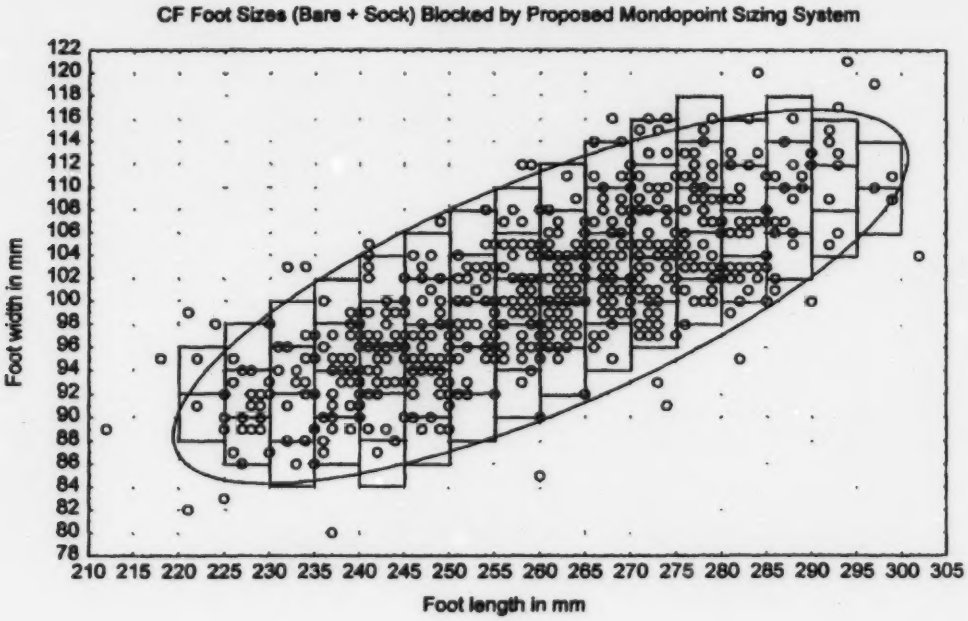
ANNEX B:
Results of DCIEM Fit and Adjustment Tests

ANNEX B: Results of DCIEM Fit and Adjustment tests

B1. Assumptions

Requirement 3.3.1 of the Human Factors (HF) Performance Requirements and Test Protocols attached to the Request for Proposals (RFP) for the Wet Weather Boot (WWB) states "Fit shall accommodate 95% of all CFLF (males and females)". The following discussion of the results of tests done and data collected describes the rationale used to determine compliance with this requirement.

CFLF, male and female, bare feet were measured during a recent anthropometric survey[1]. In a separate study done at DCIEM (unpublished data) the length and width of 24 feet were measured, with and without the Canadian Prototype Sock, General Purpose (DSSPM 372-99). The sock added 2.9 ± 2.6 mm (mean ± s.d.) to the length of a bare foot, and 4.8 ± 2.9 mm to the width. The figure below shows the distribution of foot length and width of the survey[1] augmented by mean sock thickness.



Each small circle in the figure represents a subject in the survey. The oval superimposed on the plot is a computer-generated ellipse depicting the area in which there is a 95% probability that a measurement will fall. This confidence ellipse, therefore, was chosen as the definition of the "95% of all CFLF (males and females)" that shall be accommodated.

A Mondopoint Sizing System was selected by the CTS footwear team as the means of defining the number and critical dimensions of sizes required to fit 95% of the CFLF population. The definition of Mondopoint (taken from the glossary of terms published on the internet by City International Company Limited, www.cityintl.com) is "an intended international method of designating shoe sizes. It provides that the marking should consist of two numbers: (1) a number corresponding to the length in millimeters (measured weight-on and wearing hose) of the average foot fitted; and (2) a number corresponding to the joint width in millimeters (measured weight-on and wearing hose) of the average foot fitted. Mondopoint has been adopted by the British Standards Institution and the International Standards Organization, which have specified that the size interval should be 5 mm or 7 mm, depending on the type of footwear." It was further decided that footwear size interval for lengths will be 5 mm, and for width will be 4 mm.

After several iterations, 66 sizes were chosen using the definition of the Mondopoint intervals as variables and the 95% confidence ellipse of population as the target fit. The sizes are shown as rectangles in the above figure. The proposed sizing system was tested using the anthropometry data, and was found to have a theoretical coverage of 96.1% of the population. The final step in determining the 95% fit compliance of the boot submissions was to confirm that the sizes produced actually fit the feet for which they were designed.

B2. Pilot Fit Trial

Preceding the formal bid evaluation, described in the main body of this report, DCIEM performed a pilot fit trial as a first step in determining whether the boots submitted actually fit the target population. Army personnel at CFB Petawawa were chosen as test subjects. Measurements were taken of the participants' bare feet. The measurements included foot length, foot width, heel-to-ankle girth, and ball-of-foot girth. The measurements of foot length and width were augmented by sock thickness, as was done with the above figure. To get a better idea of the range of foot sizes which found the fit of these boots "acceptable", individuals whose foot-plus-sock measurements fell within ± 2 sizes in length and ± 2 sizes in width of the three sizes of the three bid boots were used in the trial. Subjects were briefed on the guidelines defining a good fit and on the rating scale to be used. After the briefing, they tried on the boots and rated the fit after a short march (1 km) over a predetermined course with varied terrain. A five point rating scale was used where 1 = Too Small, 2 = Acceptable but a little snug, 3 = OK, 4 = Acceptable but a little loose, 5 = Too Big. Nine (9) personnel tried on the size 255/100 boots, fifteen (15) tried on the size 265/104 boots, and eight (8) tried on the 270/102 boots.

B3. Bid Evaluation Trial

During session 1 of the formal bid evaluation, approximately 80 personnel at CFB Petawawa took part in an initial fit trial. These personnel had their feet measured previously, and were selected for the bid evaluation trial because their foot measurements were within the range (for length and width) for which the boots were designed. As mentioned in other parts of this report, the soldiers were divided into a controlled and an uncontrolled group, and the controlled group received two pairs of boots (two different contenders) while the uncontrolled group received only one pair. Once fitted, the participants performed a short march (1 km), consisting of a varying terrain and grades (i.e. up-slope, down-slope and side-slope), for each pair of boots. Participants completed a Fit Questionnaire at the completion of each circuit. HF observers noted any associated sizing and fitting concerns.

At the completion of the three month trial, participants completed an Exit Questionnaire. One part of the questionnaire asked the participants to reassess the fit of their boots. Exit focus groups were also conducted where all aspects of the boots being trialled were discussed, including fit.

B4. Results

In the pilot fit trial, personnel whose foot measurements fell within the range of length and width for which the boot was designed rated the fit as acceptable for all three sizes of all three boot contenders.

During the initial fit portion of the bid evaluation trial, most personnel found an acceptable overall fit with the boots they were issued. There were three immediate complaints that could not be resolved with any of the boots and the individuals were therefore dismissed. These personnel possessed insufficient girth in the ball-of-foot and heel-ankle areas to maintain a secure (no foot movement inside the boot) fit, no matter how tight the laces were adjusted. Others with similar problems were excused between sessions 1 and 2, and an attempt was made to redistribute the boots to members of the uncontrolled group to keep the numbers in the controlled group up.

The most reliable data acquired with respect to fit was from the controlled group. HF observers were present at all controlled activities and questions regarding fit were asked regularly. The results from the fit questionnaires of the controlled group are included at Annex C. Not all members of the controlled group were available for the final session, so only the results of the 28 who completed the Exit Questionnaire are included. This translates to n = 17 for boots A and B and n = 22 for boot C, where n is the number of participants wearing that boot type.

The results from the initial fit portion of the bid evaluation showed that, as far as length and width were concerned, the participants found an acceptable fit with all boots. The overall acceptability of fit, however, was only 82% for boot C (Table C-1). Although boots A and B, for some participants, could have been better designed in the toes and width (split 50/50 as far as being too big or too small, Table C-2), and arch support (all complaints being there was not enough, Table C-2), the overall fit rating was acceptable (Table C-1). The low overall fit rating of boot C (82%) was mostly as a result of a poor heel fit (81%) of which the majority of complaints were that the heel was too big (Table C-2), and poor heel support (86%) of which the majority of complaints said there was not enough (Table C-2). This is further reinforced by the fit results of the Exit Questionnaire (Table C-3). The overall fit of both boots A and B is rated acceptable by 100% of the participants, and of boot C is rated as acceptable by only 86% of the participants. After having worn boot C for approximately 3 months, approximately half of the participants were convinced that the heel was too big and the toe box was too small.

B5. Conclusions

The size of the foot for which the boot was designed, as far as the length and the width of the foot are concerned, was confirmed for this group of people, and via extrapolation of this result, it was estimated that the "95% fit" criterion would be satisfied with 66 sizes.

The overall fit of boots A and B was rated as acceptable. Improvements in the proportions of the heel (smaller) and toe areas (larger) of the boot as compared to the length and width of the boot are required for boot C.

References:

1. Chamberland A, Carrier R, Forest F, and Hachez G. "1997 Anthropometric Survey of the Land Forces" DCIEM Contract Report 98-CR-15. March 1998.

ANNEX C:
Data in Support of the DCIEM Fit and Adjustment Tests

ANNEX C: Data in support of the DCIEM Fit and Adjustment Tests

Each participant in the controlled trial was issued two different pairs of boots, to compare two of the three boot bid submissions. Participants were issued the boots based on the length and width of their feet. Two other foot measurements taken were heel-to-ankle girth and ball-of-foot girth. Once fitted, the participants performed a short marching circuit (1 km) consisting of a varying terrain and grades (i.e. up-slope, down-slope and side-slope) for each pair of boots. Participants completed a Fit Questionnaire at the completion of each marching circuit. HF observers noted any associated sizing and fitting concerns.

The following two tables of results are for the Bid Evaluation (Initial) Fit Questionnaires. The results only include the 28 participants that completed the Exit Questionnaires. The first table indicates acceptance only and gives no indication of "degree of acceptability". The second table should not be interpreted as an acceptability scale, rather as a "what (feature) could be better and how (bigger or smaller)".

Fit and Adjustability	User Acceptance Rating ≥ 4		
	A	B	C
Boot Height	100%	100%	100%
Calf	100%	100%	100%
Ankle	100%	100%	90%
Heel	100%	100%	81%
Instep	100%	100%	95%
Toes	88%	94%	90%
Width	82%	94%	90%
Sole Length	100%	94%	95%
Arch Support	94%	94%	95%
Ankle Support	100%	100%	90%
Heel Support	94%	100%	86%
Overall Fit	100%	94%	82%

Table C-1. Overall acceptance ratings of the wet weather boot contenders.

Fit and Adjustability	Boot A			Boot B			Boot C		
	Too Small	OK	Too Big	Too Small	OK	Too Big	Too Small	OK	Too Big
Boot Height	0%	93%	7%	0%	94%	6%	0%	83%	17%
Calf	7%	93%	0%	13%	87%	0%	0%	94%	6%
Ankle	0%	81%	19%	7%	93%	0%	0%	74%	26%
Heel	7%	93%	0%	7%	93%	0%	11%	53%	37%
Instep	0%	93%	7%	7%	93%	0%	16%	79%	5%
Toes	20%	60%	20%	13%	67%	13%	17%	83%	0%
Width	13%	73%	13%	31%	56%	13%	11%	84%	5%
Sole Length	0%	100%	0%	0%	93%	7%	0%	94%	6%
Arch Support	60%	40%	0%	40%	53%	7%	22%	78%	0%
Ankle Support	19%	81%	0%	6%	94%	0%	17%	83%	0%
Heel Support	14%	79%	7%	0%	100%	0%	37%	53%	11%
Overall Fit	7%	87%	7%	0%	93%	7%	11%	68%	21%

Table C-2. Percentage of subjects rating boot features as too small, OK, or too big at the initial fit trial.

The Exit questionnaire results below indicate the final fit of the boots. These results are also based on the 28 participants that completed the Exit Questionnaires.

Fit and Adjustability	User Acceptance Rating ≥ 4		
	A	B	C
Overall Rating – Fit	100%	100%	86%

Fit and Adjustability	Boot A			Boot B			Boot C		
	Too Small	OK	Too Big	Too Small	OK	Too Big	Too Small	OK	Too Big
Calf	0%	94%	6%	0%	100%	0%	5%	90%	5%
Ankle	0%	94%	6%	0%	88%	12%	14%	67%	19%
Heel	0%	100%	0%	0%	100%	0%	5%	47.5%	47.5%
Instep	6%	88%	6%	6%	82%	12%	10%	86%	5%
Toes	12%	88%	0%	0%	100%	0%	47.5%	47.5%	5%
Width	0%	88%	12%	0%	88%	12%	14%	81%	5%
Sole Length	0%	94%	6%	0%	94%	6%	5%	66%	29%
Boot Height	12%	88%	0%	0%	100%	0%	5%	76%	19%

Table C-3. Percentage of subjects rating boot features as too small, OK, or too big as part of the Exit Questionnaire.

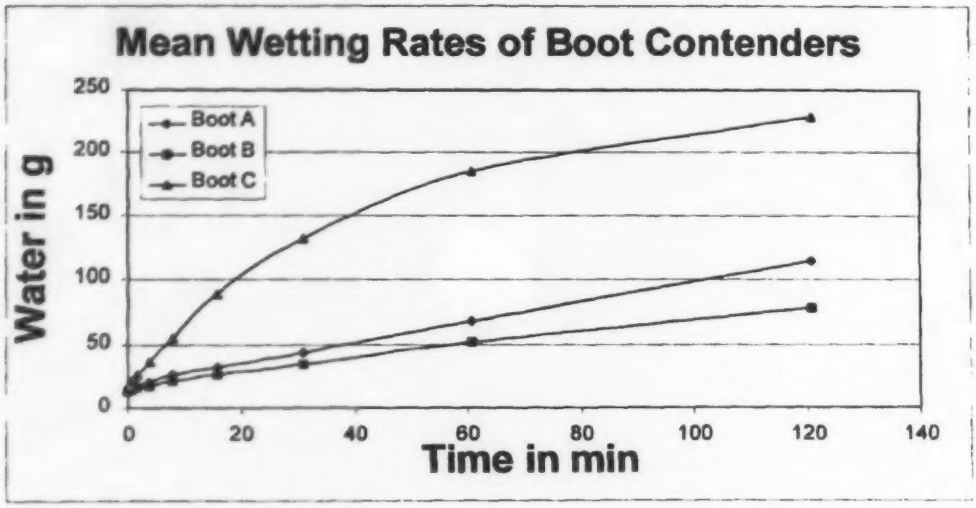
ANNEX D:
DCIEM Results of
Water Resistance Lab Tests

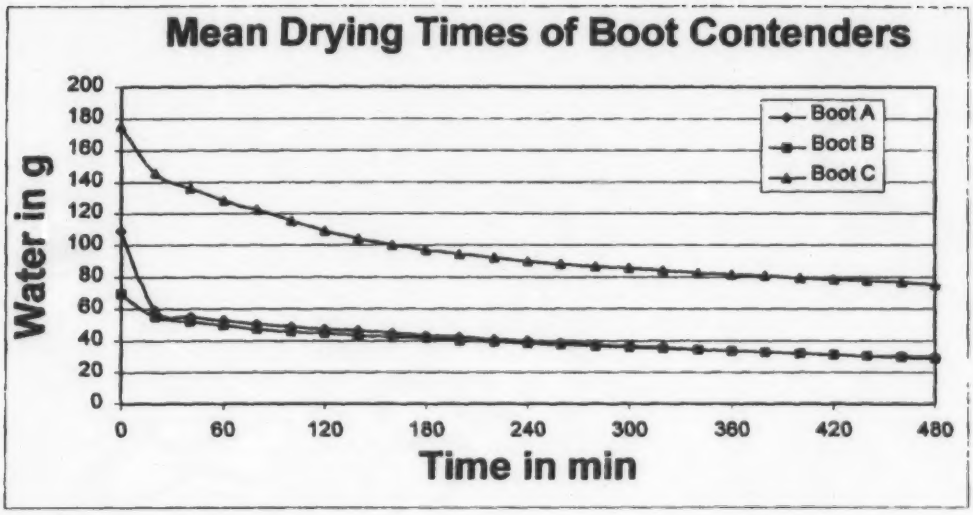
ANNEX D: DCIEM Results of Water Resistance Lab Tests

Water resistance was the eighth of twelve human factors performance requirements for evaluating the Boots, Combat, Wet Weather. Water resistance was defined as the degree to which the boot repels water (keep weight down) and prevents moisture from reaching the foot (keep foot comfortable). Tests to assess some of the elements of water resistance, as defined in the performance specification, have been completed at DCIEM (Defence and Civil Institute of Environmental Medicine, Toronto, Canada).

To assess the water repelling criterion, a boot laced onto a mannequin foot, was placed in a container of water such that the water level rose to a height of approximately 6 inches on the outside of the boot for a period of 2 hours. The boot was then removed from the mannequin foot and allowed to dry while hanging upside down by its laces on a stand on a scale. The weighing was done using a digital electronic scale (Sartorius Corp, Edgewood, NY) at predetermined intervals during the wetting phase, and via a computer which interrogated the scale and recorded the results every 20 minutes during the drying phase. This procedure was performed three times on each boot. The wetting, drying and weighing were all done in a test chamber whose temperature and humidity were controlled (T = 16.0 ± 1.0 °C, RH = 46 ± 5%).

The results of the wetting and drying tests were averaged for each boot and the following two graphs show the results.





Boots A and B displayed very similar results in both wetting and drying results and Boot C picked up approximately twice as much water as either A or B and retained it for a longer period of time.

After 2 hours of wetting, Boot A picked up 114 ± 49 g water, Boot B picked up 78 ± 29 g water, and Boot C picked up 229 ± 20 g water. After 2 hours of drying, 48 ± 5.7 g water remained in Boot A, 45 ± 13.7 g water remained in Boot B, and 109 ± 7.1 g water remained in Boot C. All three boots gained less than 350 g water during the 2 hour wetting test and had less than 175 g water remaining in the boot after a two hour drying period. All three boots are therefore compliant as per the Water Resistance Test 8.2.1.

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